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2025 *Activity Report*

RESEARCH CENTRE: **Inria Centre at the University of Bordeaux**

IN PARTNERSHIP WITH: **Université de Bordeaux, CNRS, Bordeaux INP**

Project-Team

MNEMOSYNE

Mnemonic Synergy

In collaboration with Laboratoire Bordelais de Recherche en Informatique (LaBRI)

Project-Team MNEMOSYNE

Creation of the Project-Team: 2014 July 01

Each year, Inria research teams publish an Activity Report presenting their work and results over the reporting period. These reports follow a common structure, with some optional sections depending on the specific team. They typically begin by outlining the overall objectives and research programme, including the main research themes, goals, and methodological approaches. They also describe the application domains targeted by the team, highlighting the scientific or societal contexts in which their work is situated. The reports then present the highlights of the year, covering major scientific achievements, software developments, or teaching contributions. When relevant, they include sections on software, platforms, and open data, detailing the tools developed and how they are shared. A substantial part is dedicated to new results, where scientific contributions are described in detail, often with subsections specifying participants and associated keywords. Finally, the Activity Report addresses funding, contracts, partnerships, and collaborations at various levels, from industrial agreements to international cooperations. It also covers dissemination and teaching activities, such as participation in scientific events, outreach, and supervision. The document concludes with a presentation of scientific production, including major publications and those produced during the year.

Keywords

Computer sciences and digital sciences

A1.1.12. – Non-conventional architectures

A1.5. – Complex systems

A3.1.1. – Modeling, representation

A3.1.7. – Open data

A3.2.2. – Knowledge extraction, cleaning

A3.2.5. – Ontologies

A3.3. – Data and knowledge analysis

A3.3.2. – Data mining

A5.1.1. – Engineering of interactive systems

A5.1.2. – Evaluation of interactive systems

A5.2. – Data visualization

A5.3.3. – Pattern recognition

A5.7.1. – Sound

A5.7.3. – Speech

A5.7.4. – Analysis

A5.8. – Natural language processing

A5.9.1. – Sampling, acquisition

A5.10.5. – Robot interaction (with the environment, humans, other robots)

A5.10.8. – Cognitive robotics and systems

A5.11.1. – Human activity analysis and recognition

A7.1. – Algorithms

A9. – Artificial intelligence

A9.2. – Machine learning

A9.2.1. – Supervised learning

A9.2.2. – Unsupervised learning

A9.2.3. – Reinforcement learning

A9.2.4. – Optimization and learning

A9.2.6. – Neural networks

A9.2.8. – Deep learning

A9.5. – Robotics and AI

A9.8. – Reasoning

A9.11. – Generative AI

A9.12.1. – Object recognition

A9.12.2. – Activity recognition

Other research topics and application domains

B1.2. – Neuroscience and cognitive science

B1.2.1. – Understanding and simulation of the brain and the nervous system

B1.2.2. – Cognitive science

B2.2.6. – Neurodegenerative diseases

B8.5.2. – Crowd sourcing

B9.1.1. – E-learning, MOOC

B9.5.1. – Computer science

B9.6.8. – Linguistics

B9.7. – Knowledge dissemination

B9.8. – Reproducibility

B9.11.1. – Environmental risks

Contents

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2 Overall objectives

2.1 Summary

At the frontier between integrative and computational neuroscience, we propose to model the brain as a system of active memories in synergy and in interaction with the internal and external world and to simulate it *as a whole and in situation*.

In integrative and cognitive neuroscience (*cf.* § 3.1), on the basis of current knowledge and experimental data, we develop models of the main cerebral structures, taking a specific care of the kind of mnemonic function they implement and of their interface with other cerebral and external structures. Then, in a systemic approach, we build the main behavioral loops involving these cerebral structures, connecting a wide spectrum of actions to various kinds of sensations. We observe at the behavioral level the properties emerging from the interaction between these loops.

We claim that this approach is particularly fruitful for investigating cerebral structures like the basal ganglia and the prefrontal cortex, difficult to comprehend today because of the rich and multimodal information flows they integrate. We expect to cope with the high complexity of such systems, inspired by behavioral and developmental sciences, explaining how behavioral loops gradually incorporate in the system various kinds of information and associated mnesic representations. As a consequence, the underlying cognitive architecture, emerging from the interplay between these sensations-actions loops, results from a *mnemonic synergy*.

In computational neuroscience (*cf.* § 3.2), we concentrate on the efficiency of local mechanisms and on the effectiveness of the distributed computations at the level of the system. We also take care of the analysis of their dynamic properties, at different time scales. These fundamental properties are of high importance to allow the deployment of very large systems and their simulation in a framework of high performance computing

Running simulations at a large scale is particularly interesting to evaluate over a long period a consistent and relatively complete network of cerebral structures in realistic interaction with the external and internal world. We face this problem in the domain of autonomous robotics (*cf.* § 3.4) and ensure a real autonomy by the design of an artificial physiology and convenient learning protocoles.

We are convinced that this original approach also permits to revisit and enrich algorithms and methodologies in machine learning (*cf.* § 3.3) and in autonomous robotics (*cf.* § 3.4), in addition to elaborate hypotheses to be tested in neuroscience and medicine, while offering to these latter domains a new ground of experimentation similar to their daily experimental studies.

3 Research program

3.1 Integrative and Cognitive Neuroscience

The human brain is often considered as the most complex system dedicated to information processing. This multi-scale complexity, described from the metabolic to the network level, is particularly studied in integrative neuroscience, the goal of which is to explain how cognitive functions (ranging from sensorimotor coordination to executive functions) emerge from (are the result of the interaction of) distributed and adaptive computations of processing units, displayed along neural structures and information flows. Indeed, beyond the astounding complexity reported in physiological studies, integrative neuroscience aims at extracting, in simplifying models, regularities at various levels of description. From a mesoscopic point of view, most neuronal structures (and particularly some of primary importance like the cortex, cerebellum, striatum, hippocampus) can be described through a regular organization of information flows and homogenous learning rules, whatever the nature of the processed information. From a macroscopic point of view, the arrangement in space of neuronal structures within the cerebral architecture also obeys a functional logic, the sketch of which is captured in models describing the main information flows in the brain, the corresponding loops built in interaction with the external and internal (bodily and hormonal) world and the developmental steps leading to the acquisition of elementary sensorimotor skills up to the most complex executive functions.

In summary, integrative neuroscience builds, on an overwhelming quantity of data, a simplifying and interpretative grid suggesting homogenous local computations and a structured and logical plan for the development of cognitive functions. They arise from interactions and information exchange between neuronal structures and the external and internal world and also within the network of structures.

This domain is today very active and stimulating because it proposes, of course at the price of simplifications, global views of cerebral functioning and more local hypotheses on the role of subsets of neuronal structures in cognition. In the global approaches, the integration of data from experimental psychology and clinical studies leads to an overview of the brain as a set of interacting memories, each devoted to a specific kind of information processing [54]. It results also in longstanding and very ambitious studies for the design of cognitive architectures aiming at embracing the whole cognition. With the notable exception of works initiated by [49], most of these frameworks (e.g. Soar, ACT-R), though sometimes justified on biological grounds, do not go up to a *connectionist* neuronal implementation. Furthermore, because of the complexity of the resulting frameworks, they are restricted to simple symbolic interfaces with the internal and external world and to (relatively) small-sized internal structures. Our main research objective is undoubtly to build such a general purpose cognitive architecture (to model the brain *as a whole* in a systemic way), using a connectionist implementation and able to cope with a realistic environment.

3.2 Computational Neuroscience

From a general point of view, computational neuroscience can be defined as the development of methods from computer science and applied mathematics, to explore more technically and theoretically the relations between structures and functions in the brain [56, 47]. During the recent years this domain has gained an increasing interest in neuroscience and has become an essential tool for scientific developments in most fields in neuroscience, from the molecule to the system. In this view, all the objectives of our team can be described as possible progresses in computational neuroscience. Accordingly, it can be underlined that the systemic view that we promote can offer original contributions in the sense that, whereas most classical models in computational neuroscience focus on the better understanding of the structure/function relationship for isolated specific structures, we aim at exploring synergies between structures. Consequently, we target interfaces and interplay between heterogenous modes of computing, which is rarely addressed in classical computational neuroscience.

We also insist on another aspect of computational neuroscience which is, in our opinion, at the core of the involvement of computer scientists and mathematicians in the domain and on which we think we could particularly contribute. Indeed, we think that our primary abilities in numerical sciences imply that our developments are characterized above all by the effectiveness of the corresponding computations: we provide biologically inspired architectures with effective computational properties, such as robustness to noise, self-organization, on-line learning. We more generally underline the requirement that our models must also mimick biology through its most general law of homeostasis and self-adaptability in an unknown and changing environment. This means that we propose to numerically experiment such models and thus provide effective methods to falsify them.

Here, computational neuroscience means mimicking original computations made by the neuronal substratum and mastering their corresponding properties: computations are distributed and adaptive; they are performed without an homonculus or any central clock. Numerical schemes developed for distributed dynamical systems and algorithms elaborated for distributed computations are of central interest here [43, 42] and were the basis for several contributions in our group [55, 51, 57]. Ensuring such a rigor in the computations associated to our systemic and large scale approach is of central importance.

Equally important is the choice for the formalism of computation, extensively discussed in the connectionist domain. Spiking neurons are today widely recognized of central interest to study synchronization mechanisms and neuronal coupling at the microscopic level [48]; the associated formalism [58] can be possibly considered for local studies or for relating our results with this important domain in connectionism. Nevertheless, we remain mainly at the mesoscopic level of modeling, the level of the neuronal population, and consequently interested in the formalism developed for dynamic neural fields [52], that demonstrated a richness of behavior [53] adapted to the kind of phenomena we wish to manipulate at this level of description. Our group has a long experience in the study and adaptation of the properties of neural fields [51, 50] and their use for observing the emergence of typical cortical properties [45]. In the envisioned development of more complex architectures and interplay between structures, the exploration of mathematical properties such as stability and boundedness and the observation of emerging phenomena is one important objective. This objective is also associated with that of capitalizing our experience and promoting good practices in our software production.

In summary, we think that this systemic approach also brings to computational neuroscience new case studies where heterogenous and adaptive models with various time scales and parameters have to be considered jointly to obtain a mastered substratum of computation. This is particularly critical for large scale deployments.

3.3 Machine Learning

The adaptive properties of the nervous system are certainly among its most fascinating characteristics, with a high impact on our cognitive functions. Accordingly, machine learning is a domain [46] that aims at giving such characteristics to artificial systems, using a mathematical framework (probabilities, statistics, data analysis, etc.). Some of its most famous algorithms are directly inspired from neuroscience, at different levels. Connectionist learning algorithms implement, in various neuronal architectures, weight update rules, generally derived from the hebbian rule, performing non supervised (e.g. Kohonen self-organizing maps), supervised (e.g. layered perceptrons) or associative (e.g. Hopfield recurrent network) learning. Other algorithms, not necessarily connectionist, perform other kinds of learning, like reinforcement learning. Machine learning is a very mature domain today and all these algorithms have been extensively studied, at both the theoretical and practical levels, with much success. They have also been related to many functions (in the living and artificial domains) like discrimination, categorisation, sensorimotor coordination, planning, etc. and several neuronal structures have been proposed as the substratum for these kinds of learning [44, 40]. Nevertheless, we believe that, as for previous models, machine learning algorithms remain isolated tools, whereas our systemic approach can bring original views on these problems.

At the cognitive level, most of the problems we face do not rely on only one kind of learning and require instead skills that have to be learned in preliminary steps. That is the reason why cognitive architectures are often referred to as systems of memory, communicating and sharing information for problem solving. Instead of the classical view in machine learning of a flat architecture, a more complex network of modules must be considered here, as it is the case in the domain of deep learning. In addition, our systemic approach brings the question of incrementally building such a system, with a clear inspiration from developmental sciences. In this perspective, modules can generate internal signals corresponding to internal goals, predictions, error signals, able to supervise the learning of other modules (possibly endowed with a different learning rule), supposed to become autonomous after an instructing period. A typical example is that of episodic learning (in the hippocampus), storing declarative memory about a collection of past episods and supervising the training of a procedural memory in the cortex.

At the behavioral level, as mentioned above, our systemic approach underlines the fundamental links between the adaptive system and the internal and external world. The internal world includes proprioception and interoception, giving information about the body and its needs for integrity and other fundamental programs. The external world includes physical laws that have to be learned and possibly intelligent agents for more complex interactions. Both involve sensors and actuators that are the interfaces with these worlds and close the loops. Within this rich picture, machine learning generally selects one situation that defines useful sensors and actuators and a corpus with properly segmented data and time, and builds a specific architecture and its corresponding criteria to be satisfied. In our approach however, the first question to be raised is to discover what is the goal, where attention must be focused on and which previous skills must be exploited, with the help of a dynamic architecture and possibly other partners. In this domain, the behavioral and the developmental sciences, observing how and along which stages an agent learns, are of great help to bring some structure to this high dimensional problem.

At the implementation level, this analysis opens many fundamental challenges, hardly considered in machine learning : stability must be preserved despite on-line continuous learning; criteria to be satisfied often refer to behavioral and global measurements but they must be translated to control the local circuit level; in an incremental or developmental approach, how will the development of new functions preserve the integrity and stability of others? In addition, this continous re-arrangement is supposed to involve several kinds of learning, at different time scales (from msec to years in humans) and to interfer with other phenomena like variability and meta-plasticity.

In summary, our main objective in machine learning is to propose on-line learning systems, where several modes of learning have to collaborate and where the protocoles of training are realistic. We promote here a *really autonomous* learning, where the agent must select by itself internal resources (and build them if not available) to evolve at the best in an unknown world, without the help of any *deus-ex-machina* to define parameters, build corpus and define training sessions, as it is generally the case in machine learning. To that end, autonomous robotics (*cf.* § 3.4) is a perfect testbed.

3.4 Autonomous Robotics

Autonomous robots are not only convenient platforms to implement our algorithms; the choice of such platforms is also motivated by theories in cognitive science and neuroscience indicating that cognition emerges from interactions of the body in direct loops with the world (*embodiment of cognition* [41]). In addition to real robotic platforms, software implementations of autonomous robotic systems including components dedicated to their body and their environment will be also possibly exploited, considering that they are also a tool for studying conditions for a real autonomous learning.

A real autonomy can be obtained only if the robot is able to define its goal by itself, without the specification of any high level and abstract cost function or rewarding state. To ensure such a capability, we propose to endow the robot with an artificial physiology, corresponding to perceiving some kind of pain and pleasure. It may consequently discriminate internal and external goals (or situations to be avoided). This will mimick circuits related to fundamental needs (e.g. hunger and thirst) and to the preservation of bodily integrity. An important objective is to show that more abstract planning capabilities can arise from these basic goals.

A real autonomy with an on-line continuous learning as described in § 3.3 will be made possible by the elaboration of protocols of learning, as it is the case, in animal conditioning, for experimental studies where performance on a task can be obtained only after a shaping in increasingly complex tasks. Similarly, developmental sciences can teach us about the ordered elaboration of skills and their association in more complex schemes. An important challenge here is to translate these hints at the level of the cerebral architecture.

As a whole, autonomous robotics provide a way to assess the consistency of our models in realistic conditions of use and offer our colleagues in behavioral sciences an object of study and comparison, regarding behavioral dynamics emerging from interactions with the environment, also observable at the neuronal level.

In summary, our main contribution in autonomous robotics is to make autonomy possible, by various means corresponding to endow robots with an artificial physiology, to give instructions in a natural and incremental way and to prioritize the synergy between reactive and robust schemes over complex planning structures.

4 Application domains

4.1 Overview

Modeling the brain to emulate cognitive functions offers direct and indirect application domains. Our models are designed to be confronted to the reality of life sciences and to make predictions in neuroscience and in the medical domain. Our models also have an impact in digital sciences; their performances can be questioned in informatics, their algorithms can be compared with models in machine learning and artificial intelligence, their behavior can be analysed in human-robot interaction. But since what they produce is related to human thinking and behavior, applications will be also possible in various domains of social sciences and humanities.

4.2 Applications in life sciences

One of the most original specificity of our team is that it is part of a laboratory in Neuroscience (with a large spectrum of activity from the molecule to the behavior), focused on neurodegenerative diseases and consequently working in tight collaboration with the medical domain. Beyond data and signal analysis where our expertise in machine learning may be possibly useful, our interactions are mainly centered on the exploitation of our models. They will be classically regarded as a way to validate biological assumptions and to generate new hypotheses to be investigated in the living. Our macroscopic models and their implementation in autonomous robots will allow an analysis at the behavioral level and will propose a systemic framework, the interpretation of which will meet aetiological analysis in the medical domain and interpretation of intelligent behavior in cognitive neuroscience and related domains like for example educational science.

The study of neurodegenerative diseases is targeted because they match the phenomena we model. Particularly, the Parkinson disease results from the death of dopaminergic cells in the basal ganglia, one of the main systems that we are modeling. The Alzheimer disease also results from the loss of neurons, in several cortical and extracortical regions. The variety of these regions, together with large mnesic and cognitive deficits, require a systemic view of the cerebral architecture and associated functions, very consistent with our approach.

4.3 Application in digital sciences

Of course, digital sciences are also impacted by our researches, at several levels. At a global level, we will propose new control architectures aimed at providing a higher degree of autonomy to robots, as well as machine learning algorithms working in more realistic environment. More specifically, our focus on some cognitive functions in closed loop with a real environment will address currently open problems. This is obviously the case for planning and decision making; this is particularly the case for the domain of affective computing, since motivational characteristics arising from the design of an artificial physiology allow to consider not only cold rational cognition but also hot emotional cognition. The association of both kinds of cognition is undoubtly an innovative way to create more realistic intelligent systems but also to elaborate more natural interfaces between these systems and human users.

At last, we think that our activities in well-founded distributed computations and high performance computing are not just intended to help us design large scale systems. We also think that we are working here at the core of informatics and, accordingly, that we could transfer some fundamental results in this domain.

4.4 Applications in human sciences

Because we model specific aspects of cognition such as learning, language and decision, our models could be directly analysed from the perspective of educational sciences, linguistics, economy, philosophy and ethics.

Futhermore, our implication in science outreach actions, including computer science teaching in secondary and primary school, with the will to analyse and evaluate the outcomes of these actions, is at the origin of building a link between our research in computational learning and human learning, providing not only tools but also new modeling paradigms.

5 Social and environmental responsibility

5.1 Footprint of research activities

As part of the Institute of Neurodegenerative Diseases that developed a strong commitment to the environment, we take our share in the reduction of our carbon footprint by deciding to reduce our commuting footprint and the number of yearly travels to conference.

6 Highlights of the year

N. Rougier led a comment in Nature (2025) [11] about the importance of sharing and supporting software in research addressed at both scientists and stakeholders. This reinforces our long-term commitment to open science.

P. Bernard and X. Hinaut released a new major version (0.4.*) of the ReservoirPy library. The refactoring of the code was targeted to include a long-awaited feature: the integration of the JAX backend, enabling a significant speedup for reservoirs with more than 1,000 neurons (for both CPU and GPU). This will enable new experiments with deep architectures and new potential collaborations.

7 Latest software developments, platforms, open data

7.1 Latest software developments

7.1.1 ReservoirPy

Name: Reservoir computing with Python

Keywords: Reservoir Computing, Physical Computing

Scientific Description: Reservoirs Computing is based on random Recurrent Neural Networks (RNNs). ESNs are a particular kind of networks with or without leaking neurons. The computing principle can be seen as a temporal SVM (Support Vector Machine): random projections are used to make dimensionality expansion of the inputs. The input stream is projected to a random recurrent layer and a linear output layer (called "read-out") is modified by learning. This training is often done offline, but can also be done in an online fashion.

Compared to other RNNs, the input layer and the recurrent layer (called "reservoir") do not need to be trained. For other RNNs, the structure of the recurrent layer evolves in most cases by gradient descent algorithms like Backpropagation-Through-Time, which is not biologically plausible and is adapted iteratively to be able to hold a representaion of the input sequence. In contrast, the random weights of the ESN's reservoir are not trained, but are often adapted to possess the "Echo State Property" (ESP) or at least suitable dynamics to generalize. The reservoir activities include non-linear transformations of the inputs that are then exploited by a linear layer. The states of the reservoir can be mapped to the output layer by a computationally cheap linear regression. The weights of the input and recurrent layer can be scaled depending on the task at hand: these are considered as hyperparameters (i.e. parameters which are not learned) along with the leaking rate (or time constant) of neurons and the random matrix densities.

Functional Description: ReservoirPy enables the fast and efficient training of artificial recurrent neural networks.

This library provides implementations and tools for the Reservoir Computing paradigm: a way of training Recurrent Neural Networks without training all the weights, by using random projections. ReservoirPy provides an implementation only relying on general scientific librairies like Numpy and Scipy, in order to be more versatile than specific frameworks (e.g. TensorFlow, PyTorch) and provide more flexibilty to build custom architectures. Since version 0.4.1, it includes the possibility of combining NumPy with the JAX backend for GPU and CPU acceleration. It includes useful and advanced features to train reservoirs. ReservoirPy especially focuses on the Echo State Networks flavour, based on average firing rate neurons with tanh (hyperbolic tangent) activation function. External tools (such as Scikit-learn) and datasets can be easily integrated into models through dedicated interface nodes.

Reservoirs Computing is based on random Recurrent Neural Networks (RNNs). The computing principle can be seen as a temporal SVM (Support Vector Machine): random projections are used to make dimensionality expansion of the inputs towards a non-linear high-dimensional space. The input stream is projected to a random recurrent layer and a (often) linear output layer (called "read-out") is modified by learning. This training is often done offline, but can also be done in an online fashion.

Compared to other RNNs, the input layer and the recurrent layer (called "reservoir") do not need to be trained. For other RNNs, the structure of the recurrent layer are often modified by gradient descent algorithms like Backpropagation-Through-Time (BPTT). This more classical kind of learning is not biologically plausible and often needs to see the training data several time (i.e. for several epochs), whereas with Reservoir Computing training data are used once usually. In contrast, the random weights of the ESN's reservoir are not trained, but are often adapted to possess the "Echo State Property" (ESP) or at least suitable dynamics to generalize. In addition, sparse matrices are often used for these random matrices. Overall, this greatly speeds up the learning process and enables online learning, which is an advantage in many applications.

The reservoir activities include non-linear transformations of the inputs that are then exploited by a linear layer. The states of the reservoir can be mapped to the output layer by a computationally cheap linear regression. The weights of the input and recurrent layer can be scaled depending on the task at hand: these are considered as hyperparameters (i.e. parameters which are not learned) along with the leaking rate (or time constant) of neurons.

Release Contributions: Since version 0.4.1 (September 2025), the library now includes the JAX backend, offering a complementary alternative to the NumPy backend. This feature enables significant acceleration of computations, particularly for reservoirs with more than 1,000 neurons. JAX emerges as a high-performance solution thanks to its familiar syntax similar to NumPy, while delivering efficient acceleration on both CPU and GPU. In practice, training times for a 10,000-neuron reservoir are reduced by approximately sixfold compared to the NumPy-based implementation, on a laptop equipped with multiple CPU cores or a GPU with a few gigabytes of memory.

News of the Year: Within the development of the ReservoirPy library, we have released various versions from 0.3.12 to 0.4.1. A notable novelty: we started a collaboration with Jean-Loup Faulon (Micalis, Inrae, Paris) on bacterial reservoirs, along with Laura Alonso-Bartolome who started a PhD. Laura will develop reservoirs nodes based on bacteria models. We continued the collaboration with Nicolas Dubreuil at Institut d'Optique (Bordeaux) on optical reservoirs. We pursue the 16 hours of lectures for students of Institut d'Optique (Jan/Feb2026) to make them discover the general Reservoir Computing framework using simulated optical reservoir models in the library.

We created LLM based chatbot answering code and knowledge question on Reservoir Computing and ReservoirPy. It had a dedicated website no longer accessible: chat.reservoirpy.inria.fr. We showed that our developped RAG (using papers, reservoirpy code and specific data) was answering questions about code better than standard LLMs (HAL preprint hal-05132988). In our follow-up of our collaboration with Inria SISTEM and Bordeaux CHU, we published several papers: Computo (a tutorial based on RerservoirPy interface to R), hal-05392781 preprint (lessons learned from epidemic forecasting).

We presented Reservoir Computing principles and the ReservoirPy library at various conferences: AI4industry 2025 workshop (Jan25, Bordeaux), IJCNN tutorial (Jul25, Rome, Italy), ECML-PKDD tutorial (Sep25, Porto (online), Portugal), ICANN workshop (Sept25, Kaunas (online), Latvia), LACORO Summer School (Dec 25, Rancagua, Chile), and we organised a special session at IJCNN (Jul25, Rome, Italy).

We also presented RC at popular science events: Pint of Science (May25, Bordeaux), high school students for "Fête de la Science" (Oct 25, Lycée Aiguillon, FR), "Intelligences" at Cap Sciences (Bordeaux, FR). We were also invited to give particular presentations on similar topics in several labs (e.g. Inria Chile, Dec25, Santiago, LSD, Universidad de Buenos Aires, Dec25, Argentina) and at various events (e.g. ESIEA engineering school seminar week, Mar25, Dienne, FR, CESI engineering school, Apr25, Bordeaux, FR).

Within the development of the ReservoirPy library, during 2025 we have released various versions from v0.3.13 up to v0.4.1. Below is a summary of main changes. All releases details are available on GitHub.

* ReservoirPy v0.3.13 1. New node: LocalPlasticityReservoir. 2. Two additional hyper-parameter search methods: adaptive TPE (‘atpe‘) and simulated annealing (‘anneal‘). 3. RLS node can now have a forgetting factor. 4. Fix: ‘qlognormal‘ scale can now be used in hyperparameter search. 5. New argument for the Mackey-Glass timeseries generator: ‘history‘.

* ReservoirPy v0.3.13post1 1. Documentation: Fixed dataset plots, Detailed LocalPlasticityReservoir documentation, Added a gallery in API reference, Added more images in User Guide.

* ReservoirPy v0.3.14 1. Implemented small world matrix generation based on the Watts-Strogatz model. 2. Implemented clustered matrix generation based on Erdos-Rényi algorithm. 3. Implemented missing values (NaN) filtering in target data. 4. Fixed documentation for the reservoir equation.

* ReservoirPy v0.3.15 1. New method for random search with parallelization: ‘hyper.parallel_research‘. 2. Fix permission error when ReservoirPy is used by multiple users on the same machine. 3. Removed a useless logger in the *japanese_vowels* dataset.

* ReservoirPy v0.4.0 1. Major rewrite of core mechanisms for Nodes and Models with many API and internal changes. 2. New random search parallelization method: ‘hyper.parallel_research‘. 3.

New node: Edge of Stability Echo State Network (‘reservoirpy.nodes.ES2N‘). 4. Updated behavior for ‘LocalPlasticityReservoir‘ to accept any array format for its recurrent weight matrix. 5. Parallel run and parallel fit capabilities for nodes and models on multiple timeseries. 6. Stabilized the leaky-integrate-and-fire liquid state machine (‘nodes.LIF‘). 7. API changes including renaming of several parameters and node methods to better match conventions. 8. Changes to default Reservoir behavior, node state representation, and dataset outputs. 9. Multiple internal changes and removals of deprecated mechanisms such as legacy backends and modules.

* ReservoirPy v0.4.1 1. Addition of the JAX backend: nodes and models can now use JAX instead of NumPy, with most imports available under ‘reservoirpy.jax.‘. 2. Support for models with multiple inputs allowing a single input broadcast to all nodes. 3. Reintroduced ‘Model.reset‘ method. 4. Extended ‘reservoir.ESN‘ model with a ‘return_reservoir_activity‘ output option. 5. Better string representation for nodes, models, and initializers. 6. All extra dependencies can be installed via ‘pip install reservoirpy[all]‘. 7. Optimization of the ‘datasets.mackey_glass‘ method. 8. Bug fixes including removal of mandatory ‘matplotlib‘ import, corrected Ridge bias behavior, and fixed warmup argument for unsupervised parallel nodes.

URL: https://github.com/reservoirpy/reservoirpy

Publications: hal-04401731, hal-04354303, hal-04404054, hal-05132988, hal-05208084, hal-05393834, hal-05393077, hal-03699931, hal-04905975, hal-04700006, hal-04693930, hal-02595026, hal-03533731, hal-03203318, hal-03482372, hal-03203374, hal-03761440, tel-03946773, hal-03628290, hal-03780006, hal-03945994

Contact: Xavier Hinaut

Participant: 3 anonymous participants

7.1.2 AIDElibs

Name: Artificial Intelligence Devoted to Education

Scientific Description: We want to explore to what extent approaches or techniques from cognitive neuroscience related to machine learning and symbolic tools to represent knowledge, could help to better formalize human learning as studied in education sciences. . To this end, we are developing a research code for measuring learning analytics during activities with tangible objects and middleware between the major tools and algorithms used in this exploratory action of research.

Functional Description: This library includes

- the preliminary implementation of metrizable symbolic data structure allowing performing symbolic derivations using numerical embedding, in an explicitly (thus easily explainable) way, targeting reinforcement symbolic learning or open-ended creative complex problem-solving.

- a set of C/C++ routines for basic calculations, with the portions of code executed on connected objects which allow measurement of learning traces, and the control of experiments,

- C/C ++ or Javascript tools to interface the different software modules used, and a Python wrapper to develop above these functionalities.

Release Contributions: Initial version

URL: https://gitlab.inria.fr/line/aide-group/aide

Contact: Thierry Viéville

Participant: 4 anonymous participants

7.2 Open data

N.Rougier has been nominated as the representant for Open Science for the Inria Bordeaux Center and is part of the Software College of the "Comité pour la Science Ouverte".

8 New results

8.1 Overview

This year we have addressed several important questions related to our scientific positioning. Central to this positioning, we have studied and modeled bio-inspired learning mechanisms and collaborative mnesic functions (*cf.* § 8.2). We have extended our activities of exploration of higher cognitive functions, also called Metacognition (*cf.* § 8.3) and have considered how important characteristics can be associated to this framework, like symbolic abstract knowledge (*cf.* § 8.4), and oscillations (*cf.* § 8.5). Endly, we have pursued our work on language processing in birds and robots (*cf.* § 8.6).

8.2 Decision, learning and collaborative mnesic functions

Participants: Nicolas Rougier, Xavier Hinaut.

A prominent view of basal ganglia (BG)/cortical interactions relates to a form of reinforcement learning (RL), in which dopamine influx in the BG signals performance and approximates a gradient descent over many trials. However, when applied to complex, continuous and embodied sensorimotor tasks, such gradient-based RL faces major limitations. Extending the PhD work of Remy Sankar, we have thus explored an alternative based on the songbird's dual-pathway circuitry, where a cortical-like motor pathway and a BG-thalamo-cortical circuit interact during learning, with structured variability, pathway-specific plasticity, and delayed maturation, providing a substrate for guided exploration and consolidation.

We have also extended the PhD work of Naomi Chaix-Eichel and investigated the nature of splitter cells. More specifically, we investigate whether a random recurrent structure is sufficient to allow latent sequences to appear. To do so, we simulated an agent with egocentric sensory inputs that must navigate and alternate choices at intersections. We were subsequently able to identify several splitter cells inside the model. Remarkably, when we systematically lesioned the identified splitter cells, the model's behavioral performance remained intact, and new splitter cells consistently emerged through network reorganization.

We further explored the role of random recurrent architectures in supporting distributed and adaptive mnemonic functions. With collaborators at Standford Medecine [31], we showed that reservoir models could reveal how short-term synaptic depression unifies the generation of MMN (Mismatch Negativity) and P300 event-related potentials, providing a mechanistic link between neural dynamics and cognitive attention. Further, with collaborators [28], we emphasized the "less is more" principle in natural intelligence, showing how biological constraints foster efficiency, with reservoir computing enabling rapid learning from sparse data. Complementing this, [16] introduced ReMi, a low-power, data-free music generation approach using randomly initialized RNNs, highlighting the creative potential of minimalistic architectures.

Finally, within the Défi Inria LLM4Code project , we explored how LLMs (Large Language Models) can help to build generic structures (thanks to code generation) that drive autonomous agents. This bridges the emerging field of Software Engineering Agents (SWE-Agent) with agents in embodied control tasks, demonstrating the role of information access in problem-solving in simulated environments [26]. On a side path, we explored how to enhance an LLM and optimised it for answering Reservoir Computing questions and code using ReservoirPy by building a RAG (Retrieved-Augmented Generation) [25]: we obtained better performances than commercial and open source models for advanced coding questions.

8.3 Metacognition

Participants: Frédéric Alexandre, Chloé Mercier, Thierry Viéville.

In the doctoral work of Lucie Fontaine and also associated with our associate team MetaBrain (cf. section 9.1.1), we are studying the cerebral circuitry underlying fundamental mechanisms of metacognition. More precisely, we are considering the association of a cortical model, built in a predictive coding framework, with an hippocampal model [17], in order to study in more details the mechanisms of the Complementary Learning Systems theory, combining recall, replay and consolidation.

We have also evaluated the level of flexibility and other metacognitive properties in classical generative AI models [13]. We have explained in a position paper [18] why episodic memory is an important mechanism to integrate with generative AI.

In the doctoral work of Baptiste Pesquet and also associated with the ANR project Courrier (cf section 9.3.2), we have set the bases of a model of metacognitive evaluation, namely confidence, based on accumulation of evidence [19].

8.4 Integrating abstract symbolic knowledge

Participants: Frédéric Alexandre, Chloé Mercier, Margarida Romero, Thierry Viéville.

As a follow-up to our previous work, proposing to map an ontology onto a Vector Symbolic Architecture (VSA) with a partial implementation into spiking neural networks, we have finalized modeling such a mesoscopic process at a macroscopic scale. This formalism allows to integrate abstract symbolic knowledge in biologically plausible mechanisms considering more complex neural architectures, beyond what is possible at the implementation level with high dimensional vector calculus.

We have also addressed a more formal work on manipulating symbolic knowledge equipped with a metric and on applying this formalism to complex ill-defined problem-solving, allowing to explicitly introduce symbolic knowledge in usal machine learning numerical algorithms.

Both issues are in progress with journal articles in review.

8.5 Integrating oscillations

In 2025, as part of an open and reproducible science effort, we have published an article in Rescience C as a follow-up of the work of Mathilde Reynes during her Master internship [14], reproducing a model of the cortex and thalamus, originally developed in 2002 and foundational to many subsequent studies on thalamocortical oscillations, using a modern programming language and modeling paradigm. Our work demonstrates that some initial results were due to programming errors and provides recommendations for improved reproducibility.

At the microscopic scale, as part of the PhD project of Maeva Andriantsoamberomanga, we have finished elaborating our multicompartment model of the hippocampus capable of reproducing theta-nested gamma oscillations, and are currently investigating the effects of extracellular electrical stimulation on hippocampal oscillations. This work was presented at the OCNS conference in July ([32]), and a journal article is currently in preparation.

It should be noted that this year's work on oscillations was initially thought to be part of the new Inria project-team NeuroDTx instead of Mnemosyne. However, even though the initiation of NeuroDTx was encouraged by Inria and CNRS and its project proposal approved about 18 months ago, the team still hasn't been officially created due to CNRS and Inria failing to sign an agreement on intellectual property. This regrettable situation leads to unnecessary complexity regarding budgeting, reduced coherence in Mnemosyne's research project and reduced visibility for the new axis of NeuroDTx, and we sincerely hope it can be resolved in 2026.

8.6 Language processing

In order to bridge the gaps between data-scarce and data-hungry models, within the AEx BrainGPT project (cf. section 9.3.3), we started to develop hybrid architectures such as Reservoir-Transformer models. While Transformers are powerful, they exhibit quadratic complexity and lack biological plausibility in modeling cognitive functions like working memory. To address this, we introduce Echo State Transformers (EST), a hybrid architecture combining Transformer attention with Reservoir Computing [33], using trainable reservoirs as dynamic working memory units that enable constant-step complexity. Evaluated on the Time Series Library, EST achieves state-of-the-art performance in classification and anomaly detection, ranking first in two out of five categories, while offering scalable and biologically inspired alternatives to standard Transformers. This direction sets us in relation to the research on alternative models to Transformers (MAMBA, State Space Models, ...). On-going research explores how such hybrid models scale to big language data corpora. Moreover, in the context of studying parallels between human language acquisition and songbird developmental learning, we analysed song syntax in a new way [15]: we applied subword tokenization methods, commonly used in NLP, to identify meaningful chunks in canary song sequences. We compared these data-driven segmentations with our expert annotations and found significant alignment. Ongoing analyses aim to relate discovered chunks to neural activity in premotor areas like HVC. This approach not only provides a novel tool for studying birdsong structure but also offers insights into the emergence of hierarchical organization in vocal learning.

9 Partnerships and cooperations

9.1 International initiatives

9.1.1 Inria associate team not involved in an IIL or an international program

MetaBrain

Participants: Frederic Alexandre, Lucie Fontaine, Baptiste Pesquet.

The goal of this associate team with CWI in the Netherlands (2025-2027) is to define a roadmap for modeling metacognition and to specify critical aspects of its cerebral implementation. To assess such a bio-inspired model, we also plan to define relevant tasks in the domain of visual reasoning. A major objective will be to disseminate the corresponding roadmap to the Artificial Intelligence and Computational Neuroscience communities and promote a more efficient and more compatible metacognitive framework.

9.1.2 Visits to international teams

Research stays abroad Our PhD student Lucie Fontaine visited our associate team with CWI (cf. section 9.1.1) from nov. 23 to dec. 10.

9.2 European initiatives

9.2.1 Other european programs/initiatives

ETN N(AI)²TURE

Participants: Frederic Alexandre, Chloé Mercier, Thierry Vieville.

We are member of an ENLIGHT Thematic Network (ETN) called N(AI)²TURE: Network for Accessible and Interdisciplinary AI Transformation at Universities through Research and Exchange. Other members are universities of Basque County, Bordeaux, Galway, Göttingen, Groningen, Uppsala. The goal of the network (lasting from 2025 to 2027) is to structure interdisciplinary collaborations and promote critical AI literacy in higher education.

9.3 National initiatives

9.3.1 ANR DeepPool (JCJC)

Participants: Xavier Hinaut, Nathan Trouvain, Subba Oota, Axel Arnaud.

Language involves several abstraction levels of hierarchy. Most models focus on a particular level of abstraction making them unable to model bottom-up and top-down processes. Moreover, we do not know how the brain grounds symbols to perceptions and how these symbols emerge throughout development. Experimental evidence suggests that perception and action shape one-another (e.g. motor areas activated during speech perception) but the precise mechanisms involved in this action-perception shaping at various levels of abstraction are still largely unknown. X. Hinaut proposes to create a new generation of neural-based computational models of language processing and production: i.e. to (1) use biologically plausible learning mechanisms; (2) create novel sensorimotor mechanisms to account for action-perception shaping; (3) build hierarchical models from sensorimotor to sentence level; (4) embody such models in robots in order to ground semantics. The project will last five years (2022-2026). We regularly discuss with our colleague from the University of Bordeaux (Gaël Jobard).

9.3.2 ANR Courrier

Participants: Frederic Alexandre, Baptiste Pesquet.

The project with Onera (French aerospace research institute), Auctus Inria team and Incia (a neuroscience lab) will last 4 years (2025-2028). The topic is about agentivity and we study metacognition and more precisely the role of confidence and intentionality during collaboration between humans and robots.

9.3.3 Exploratory action BrainGPT

Participants: Xavier Hinaut.

In the wake of the emergence of large-scale language models such as ChatGPT, the BrainGPT project is at the forefront of research in Artificial Intelligence and Computational Neuroscience. While these models are remarkably efficient, they do not reflect how our brain processes and learns language. BrainGPT takes up the challenge by focusing on the development of models more faithful to human cognitive functioning, inspired by data from brain activity during listening or reading. The ambition is to create more efficient models, less reliant on intensive computations and massive volumes of data. BrainGPT will open new perspectives on our understanding of language and cognition. The project will last four years (2023-2026).

9.3.4 Inria Challenge LLM4Code

Participants: Xavier Hinaut.

The goal of the challenge is to leverage LLM capabilities to build code assistants that can enhance both reliability and productivity. The challenge is organized along three work packages: Self-improving code generation, Evolution of existing software, Interactive tools with AI-in-the-loop. Within Mnemosyne, we work on the generation of a controller code library generated by LLMs: we aim to generate concise code inspired from control agents to resolve tasks in various virtual environment. X. Hinaut is co-supervising the PhD of Timothé Boulet with Clément Moulin-Frier from Flowers project-team. The project will last four years (2024-2027).

9.4 Regional initiatives

9.4.1 Observatory of surveillance in democracy

Participants: Frédéric Alexandre, Melanie Romano, Nicolas Rougier.

The University of Bordeaux has labeled one of our activities as an interdisciplinary and exploratory research project. In collaboration with university partners in the field of law, the aim of this project is to understand the changes in society imposed by the development of digital surveillance technologies in a democratic context and to organize seminars and general public conferences to disseminate this information.

9.4.2 RT-HippoNeuroStim

Participant: Amélie Aussel.

The University of Bordeaux has labeled this project as an interdisciplinary and exploratory research project.

The RT-HippoNeuroStim project aims at translating the hippocampal model previously developed by A. Aussel, together with Fabien Wagner (IMN), onto the new neuromorphic computing architecture developed by the team of Timothée Levi at the IMS. This architecture is based on Field Programmable Gate Arrays (FPGA) and is much more efficient than current simulation software. We will leverage this platform to simulate the activity of the hippocampus in real time, which will greatly accelerate research on hippocampal neurostimulation.

9.4.3 PsyPhINe

Participants: Nicolas Rougier.

Project gathering researchers from: MSH Lorraine (USR3261), InterPsy (EA 4432), APEMAC, EPSaM (EA4360), Archives Henri-Poincaré (UMR7117), Loria (UMR7503) and Mnemosyne.

PsyPhiNe is a pluridisciplinary and exploratory project between philosophers, psychologists, neuroscientists and computer scientists. The goal of the project is to explore cognition and behavior from different perspectives. The project aims at exploring the idea of assignments of intelligence or intentionality, assuming that our intersubjectivity and our natural tendency to anthropomorphize play a central role: we project onto others parts of our own cognition. To test these hypotheses, we ran a series of experiments with human subject confronted to a motorized lamp that can or cannot interact with them while they're doing a specific task.

9.5 Public policy support

Participants: Frederic Alexandre, Xavier Hinaut, Nicolas Rougier, Thierry Viéville.

We had some activities related to several ministries (in addition to the ministry of research):

- Health: related to Covid hospitalization forecasting [30],
- Justice: development with the department of law of U. Bordeaux of the Observatory of Surveillance in Democracy, cf. section 9.4.1,

- Education: T. Viéville, expert for the OECD about AI Literacy Framework for Primary and Secondary Education,
- Defence: several actions of training and prospective for the ministry of Defence.

10 Dissemination

10.1 Promoting scientific activities

10.1.1 Scientific events: organisation

General chair, scientific chair F. Alexandre in charge of the scientific organization of the yearly one-week AI4I workshop (AI for Industry), 450 attendees), on 20-24 january 2025, with teaching in the morning and hands-on experiments on industrial applications in the afternoon;

X. Hinaut is part of the streering comittee of the 14th Annual Meeting of the GDR Neural Net.

Member of the conference program committees F. Alexandre, member in 2025 of the Program Committee of the conferences ACAIN; TAIMA; SAB; ICANN; Dataquitaine and AGENTICS 2025; A. Aussel, member in 2025 of the Program Committee of the conference CNS*2025; X. Hinaut is associate editor of ICDL25 and Area Chair for IJCNN25 conferences. He co-organised the BabyBot competition at ICDL25. He co-organised tutorial, workshops and/or special sessions on Reservoir Computing at IJCNN25, ECML-PKDD25, ICANN25, IJCNN25. He is the founder of SMILES workshop and organized the 4th edition at ICDL25. He is member of the TS4 group of the GDR Robotique which organises several national events per year.

Reviewer T. Viéville is ICANN, ICCN and IJCN Review Editor.

X. Hinaut is meta-reviewer for CogSci25 and ICANN25 conferences and reviewer for CogSci25, Drôles d'Objets 2025, ICDL25, IJCNN25, ICLR25 and IROS25 conferences.

10.1.2 Journal

Member of the editorial boards F. Alexandre is Academic Editor for PLOS ONE; Review Editor for Frontiers in Neurorobotics;member of the editorial board of Cognitive Neurodynamics. He was also the editor of the special issue in 2025 [23]of the bulletin of the AFIA (French National Association for AI), dedicated to the scientific activities related to AI and Neurosciences in France.

N. Rougier is Co-founder and co-editor for ReScience C and ReScience X. Associate editor for the Journal of Open Science Education, PeerJ Computer Science and Rockfeller publishing.

Reviewer - reviewing activities T. Viéville is an Associate Editor of Frontiers in Neurorobotics and Review Editor of the Canadian Journal of Learning and Technology.

X. Hinaut is reviewer for Nature Communication Engineering and Philosophical Transaction B journals.

10.1.3 Invited talks

In March, F. Alexandre was invited to give a talk to the Lyon Neuroscience research center (CRNL), about bio-inspired AI.

N.Rougier has been invited by Tübingen University (Germany), LUT University (Finland, online), 45th APLIUT conference (Colmar), Robotique et ImaginaireS (Toulouse), CIRCES annual seminar (La Rochelle), IDHN winter school (Cergy).

X. Hinaut has been invited to give talks at LACORO summer school (Rancagua, Chile, Dec25), Inria Chile (Santiago, Chile, Dec25), Laboratorio de Sistemas Dinamicos, Universidad de Buenos Aires, Dec25, Argentina), Magnet team at Inria (Lille, Nov25), IA MeetUp (Pau, Mar25), NeuroAI team at CERCO (Toulouse, Mar25), AI4industry workshop (Bordeaux, Jan25); and at various non general or student events (e.g. ESIEA engineering school seminar week, Mar25, Dienne, FR; CESI engineering school, Apr25, Bordeaux, FR).

10.1.4 Scientific expertise

F. Alexandre is an expert for the Natural Sciences and Engineering Research Council of Canada (NSERC), for the FRQNT (Fonds de Recherche du Québec Nature et Technologies), for the ANID (Agencia Nacional de Investigacion y Desarrollo) in Chile, for the European Science Foundation; expert for the National Research Agency (ANR), for international AI program of Sorbonne university, of Cergy Paris university, of university of Poitiers;

N.Rougier is an expert for Swiss Universities (Open Science).

X. Hinaut is an expert for ANR projects.

10.1.5 Research administration

F. Alexandre is member of the Project Committee of the Inria center of the university of Bordeaux and member of the board of this Committee; Corresponding scientist for Bordeaux Sud-Ouest of the Inria COERLE Operational Committee for the assesment of Legal and Ethical risks; Elected member of the board of directors of the French Society of Neuroscience;

A.Aussel is member of the Project Committee of the Inria center of the university of Bordeaux, a member of the Bordeaux Neurocampus Department concil, she has been appointed as "référente égalité" (Equality Officer) of the Institute of Neurodegenerative Diseases (IMN), and is also a member of the Bordeaux Neurocampus Parity and Inclusion Committee.

N.Rougier is member of COFIS (Advisory Board to the French Office for Scientific Integrity) and COSO (National Open Science Committee). Board member for the FRRN (French Reproducibility Network) and R4 (Réseau Régional de Recherche en Robotique).

X.Hinaut is member of the “Committee for Technological Development”(CDT), the "Committee for Research Jobs" (CER) of Inria Bordeaux Sud-Ouest, and addressee of the PlaFRIM high-performance computing cluster. He is also chair of IEEE Task Forces (TF) about: "Reservoir Computing" (co-chair), "Cognitive and Developmental Systems Technical Committee": "Language and Cognition" (vice chair) and is also member of IEEE TF "Action and Perception". He is co-chair of the "Human and Robot" (TS4) CNRS Robotics Working Group (GDR). He manages a WP in the PHDS Impulsion Bordeaux network.

10.2 Teaching - Supervision - Juries - Educational and pedagogical outreach

Many courses are given in french universities and schools of engineers at different levels (LMD) by most team members, in computer science, in applied mathematics, in neuroscience and in cognitive science.

F. Alexandre and T. Viéville have been involved in the animation and online coaching of the "Intelligence Artificielle Intelligente" citizen formation, via the creation of a MOOC, with more than 80,000 participants, allowing everyone to master these disruptive technologies by better understanding ground notions.

T. Vieville is part of teachers and education policy makers trainings regarding artificial intelligence, and is an expert for the OECD about AI Literacy Framework for Primary and Secondary Education.

10.3 Popularization

T. Viéville has co-organized and participated at large scale popularization actions (more than 500 children impacted) targeting underprivileged educational areas, proposing educational robotics activities in application of the previous multidisciplinary collaborations with learning science research.

T. Viéville has been invited for high-school interactive and participative conferences to explain artificial intelligence and computational thinking (10 interventions).

A. Aussel has been invited to multiple high-schools as part of the "Un Scientifique, une classe : Chiche !" program. She has participated in the Circuit Scientifique Bordelais as well as the "Moi Informaticienne, Moi Mathématicienne" program.

N.Rougier has been involved in more than a dozen popularization events in 2025, ranging from invited talks, round tables, interviews, podcast and animations.

X. Hinaut has been involved in several popularization events in 2025: Performances Art & Science events (Jun25, May25, Mar25), "Fête de la Science" (Oct25, Cap Sciences, Bdx), Scientific Circuit "Hors les Murs" (Oct25, Lycée Aiguillon, Lot), Open debate "Rencard du savoir « IA : un état de l'art » (Mar25, Médiathèque Gradignan), "Café IA" (Fev25, Le Node, Bdx).

10.3.1 Specific official responsibilities in science outreach structures

C. Mercier and T. Viéville are both editors of the Blog Binaire, a computer science and informatics popularization online platform managed in partnership with the French Computer Science Society, which used to be published within the very large audience newspaper LeMonde.fr, and now within the science popularization magazine La Recherche, with frequent co-publications in The Conversation.

X. Hinaut and C. Mercier co-organized, along with PhD students of the team (L. Fontaine and Y. Bendi-Ouis) the 4th edition of the hackathon Hack1robo (Oct. 2025). This event brought together students, engineers, researchers and artists to collaborate and create prototypes at the intersection of AI, robotics, cognitive science and arts, with a public presentation of the final projects opened to a large audience (around 100 attendees).

N.Rougier is vice-president of the Hypermondes association that organize the Hypermondes festical each year, mixing science and fictions. It gathered more than 14,000 people in 2025.

10.3.2 Participation in live events

F. Alexandre has participated to a debate about brain and AI in Pontonx, on november 28th.

On May, 22, F. Alexandre has given a talk presenting Generative AI during an event organized by the network Resinfo, federation of professional networks of system and network administrators in Education and Research.

He gave several presentations of AI in high-school classes for the Chiche programme: eight classes around Grenoble in March, one session in Dax in November, in Talence in April, in Gujan in November. He also made several interventions for high-school teachers in Saint-André de Cubzac in May, for the school of engineers ENSMAC in February and for the general public in librairies in Voreppe in March; He also participated to a round table about AI during the event "Le printemps des entreprises" in April in Angers. During the week of the brain (La semaine du cerveau) in March, he gave a talk to the general public about generative AI, in Lyon.

C. Mercier and F. Alexandre organized and participated to a general public session of the Palais de la Découverte about AI in June.

C. Mercier gave an invited talk and led a workshop directed towards middle-school and high-school teachers at the Pedagogical Innovation Day of the CARDIE & Inspé Orléans-Tour (June 4, 2025).

X. Hinaut and Y. Bendi-Ouis gave a invited talks at Pint of Science 2025 in Bordeaux (May25). X. Hinaut gave several Art & Science talk and performances (linked to Hack1robo spinoff project Allendia and Drôle d'Objets conference). He also discussed with high school students about AI (Mérignac, Mar25) and was then jury for these student performing an oratory debate on "Art or Science" (Mérignac, Apr25).

10.3.3 Others science outreach relevant activities

T. Viéville is part of the “Femmes et Sciences” organization, as well as a member of “Femmes et Maths”, and he is involved in gender diversity training directed towards a male audience.

Based on visits and discussions with F. Alexandre, N. Rougier, and X. Hinaut, the artist Marina Gadonneix has organized an exposition of pictures about "the geometries of mind" in the art gallery Christophe Gaillard in Paris.

A. Aussel is mentoring one female PhD student of the university of Bordeaux every year as part of the “Femmes et Sciences” organization.

11 Scientific production

11.1 Major publications

[1] F. Alexandre. ‘A global framework for a systemic view of brain modeling’. In: *Brain Informatics* 8.1 (16th Feb. 2021), p. 22. DOI: 10.1186/s40708-021-00126-4. URL: https://hal.inria.fr/hal-03143843.

[2] M. Bourdenx, A. Nioche, S. Dovero, M.-L. Arotcarena, S. M. J. Camus, G. Porras, M.-L. Thiolat, N. P. Rougier, A. Prigent, P. Aubert, S. Bohic, C. Sandt, F. Laferrière, E. Doudnikoff, N. Kruse, B. Mollenhauer, S. Novello, M. Morari, T. Leste-Lasserre, I. Trigo Damas, M. Goillandeau, C. Perier, C. Estrada, N. García Carrillo, A. Recasens, N. N. Vaikath, O. El Agnaf, M. T. Herrero, P. Derkinderen, M. Vila, J. A. Obeso, B. Dehay and E. Bezard. 'Identification of distinct pathological signatures induced by patient-derived α\$-synuclein structures in nonhuman primates'. In: *Science Advances* 6.20 (May 2020), eaaz9165. DOI: 10.1126/sciadv.aaz9165. URL: https://hal.inria.fr/hal-02611441.

[3] T. Ferté, D. Dutartre, B. P. Hejblum, R. Griffier, V. Jouhet, R. Thiébaut, P. Legrand and X. Hinaut. 'Reservoir Computing for Short High-Dimensional Time Series: an Application to SARS-CoV-2 Hospitalization Forecast'. In: ICML'24: Proceedings of the 41st International Conference on Machine Learning. Vol. 235. Proceedings of Machine Learning Research. Vienna, Austria, 8th July 2024, pp. 13570–13591. DOI: 10.5555/3692070. URL: https://hal.science/hal-04693930.

[4] A. Nioche, N. P. Rougier, M. Deffains, S. Bourgeois-Gironde, S. Ballesta and T. Boraud. 'The adaptive value of probability distortion and risk-seeking in macaques' decision-making'. In: *Philosophical Transactions of the Royal Society B: Biological Sciences* (Jan. 2021). DOI: 10.1098/rstb.2019.0668. URL: https://hal.inria.fr/hal-03005035.

[5] S. Pagliarini, A. Leblois and X. Hinaut. 'Vocal Imitation in Sensorimotor Learning Models: a Comparative Review'. In: *IEEE Transactions on Cognitive and Developmental Systems* (Nov. 2020). DOI: 10.1109/TCDS.2020.3041179. URL: https://hal.inria.fr/hal-02317144.

[6] L. Pedrelli and X. Hinaut. 'Hierarchical-Task Reservoir for Online Semantic Analysis from Continuous Speech'. In: *IEEE Transactions on Neural Networks and Learning Systems* (27th Sept. 2021). DOI: 10.1109/TNNLS.2021.3095140. URL: https://hal.inria.fr/hal-03031413.

[7] N. P. Rougier. *Scientific Visualization: Python + Matplotlib*. 15th Nov. 2021. URL: https://hal.inria.fr/hal-03427242.

[8] N. P. Rougier and G. I. Detorakis. 'Randomized Self Organizing Map'. In: *Neural Computation* (2021). URL: https://hal.inria.fr/hal-03017448.

[9] R. Sankar, N. P. Rougier and A. Leblois. 'Computational benefits of structural plasticity, illustrated in songbirds'. In: *Neuroscience & Biobehavioral Reviews* (2021). URL: https://hal.archives-ouvertes.fr/hal-03416314.

[10] A. Strock, X. Hinaut and N. P. Rougier. 'A Robust Model of Gated Working Memory'. In: *Neural Computation* (8th Nov. 2019), pp. 1–29. DOI: 10.1162/neco_a_01249. URL: https://hal.science/hal-02371659.

11.2 Publications of the year

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