

Cédric COLAS, PhD

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Education

- 2022 - **Postdoctorate in Artificial Intelligence, INRIA & MIT, Boston, USA.**
Title: *Help Me Grow: Artificial Cognitive Development via Human-Agent Interactions Supported by New Interactive, Intrinsically Motivated Program Synthesis Methods*. Project financed by a European Marie-Curie fellowship for three years: two years in the Computation Cognitive Science Lab at MIT under the supervision of Joshua Tenenbaum and one year in the Flowers team at Inria Bordeaux under the supervision of Pierre-Yves Oudeyer.
- 2017-2021 **PhD in Artificial Intelligence, INRIA - Flowers Lab, Bordeaux, FR.**
Title: *Towards Vygotskian Autotelic Agents: Learning Skills with Goals, Language and Intrinsically Motivated Deep Reinforcement Learning*. See list of publications below. Defended on June 30, 2021. I obtained the *Best PhD Thesis Award 2022* in France, from the French Artificial Intelligence Association (AFIA) with a cash prize of 1000 EUR and an *Honorary Mention* for the European Corr Bayen prize in computer science (2nd rank).
- 2016-2017 **Master in Cognitive Science, École Normale Supérieure, Paris, FR.**
Top-tier French university. Main subjects: Cognitive Neuroscience of the Prefrontal Cortex, Human Reasoning, Human Psychology Experimentations, Neuroscience of Consciousness. Results: 16.98/20, ranked 2/48.
- 2015-2016 **MSc in Biomedical Engineering, Imperial College, London, UK.**
Top-tier English university. Neurotechnology Stream. Main subjects: Biomedical Imaging, Speech Processing, Image Processing, Computational Neurosciences, Brain-Machine Interfaces. Results: 78/100, with distinctions.
- 2013-2016 **BSc and MSc in Electrical Engineering, Computer Science and Telecommunications, Supelec, Gif-sur-Yvette, FR.**
Now CentraleSupélec, 2nd best French engineering school (Usine Nouvelle ranking). The biomedical engineering MSc degree was an exchange year unlocking Supélec's MSc. Main subjects: Algorithmic, Signal Processing, Optimization, Statistics, Probability Theory. GPA: 3.7/4.

Research Projects

- Nov 2017 - **PhD Projects, INRIA - Flowers Lab, Bordeaux, FR.**
- June 2021 See list of publications below. Highlights:
- Supervised by Dr. Pierre-Yves Oudeyer and Pr. Olivier Sigaud;
 - Technical skills: self-taught in Python, Pytorch, Tensorflow, computing infrastructures, LaTeX;
 - Doctoral training: Ethics, Scientific Integrity, Answer Set Programming, Random Forest, Reproducibility, Ecological Impact of Research, Epistemology of Science;
 - Supervision experience: 2 master students, 2 bachelor students;
 - Developed collaborations with UberAI labs, Microsoft Research Montreal/Cambridge, OpenAI, SISTM team (Inria) and CNRS.
- Jun-Sept 2019 **Research Internship, Uber AI Labs, San Francisco, US.**
Project: scaling the Quality-Diversity algorithm *Map-Elites* to Deep Neuroevolution via the use of Evolution Strategies. Highlights:
- Supervised by Dr. Vashisht Madhavan and Dr. Jeff Clune;
 - Research experience: International collaboration, in a private research lab in San Francisco;
 - Technical skills: use of massively parallel computing (1000 cpus);
 - Complementary research skills: Deep NeuroEvolution (deep Genetic Algorithms, Evolution Strategies), Quality-Diversity (Map-Elites, Novelty-Search (NS), NS-ES).
 - Led to a publication at GECCO 2020 (see below).

- Jan-Jun 2017 **Master Project**, *Brain and Spine Institute - Motivation, Brain and Behavior Lab*, Paris, FR.
 Project: computational models of the exploration-exploitation dilemma in a two-armed bandit task using variational Bayesian inference. Highlights:
 - Supervised by Dr. Jean Daunizeau;
 - Complementary research skills: human cognitive modeling, models of human curiosity, variational Bayesian inference, model selection, navigating cognitive science literature.
- May-Sept 2016 **MSc Project**, *Imperial College - Brain and Behaviour Lab*, London, UK.
 Project: design of a brain-machine interface using EEG and convolutional neural networks to control an avatar in a video game for the international Cybathlon competition. Highlights:
 - Supervised by Dr. Aldo Faisal;
 - Technical skills: EEG setup, EEG data processing, Python, Theano, CNNs;
 - Research experience: collaborative project with colleague Dr. Pablo Ortega; deployment in an international competition (Cybathlon 2016, Zurich).
- Apr 2016 **MSc Project**, *Imperial College - Brain-Machine Interfaces Class*, London, UK.
 Project: offline decoding of a monkey's hand trajectories from 98 neuronal spike trains. Highlights:
 - Research experience: team project (team of 4);
 - Technical skills: feature selection, random forest, linear regression, nearest neighbors;
 - Ranked 2nd.
- Jul-Aug 2015 **Internship**, *Center of Psychiatry and Neuroscience*, Paris, FR.
 Project: I assisted a PhD student in the development of a fear renewal protocol in rats exploring wide environments. I setup the controlled experiment (rat conditioning, camera for movement detection, automatic protocol for stimuli).

Publications (peer-reviewed, main author)

- RL **Colas, C.**, Karch, T., Sigaud, O. & Oudeyer, P-Y. (2021). *Intrinsically Motivated Goal-Conditioned Reinforcement Learning: a Short Survey*. **Accepted at JAIR**. A useful review and framework to think about goal-conditioned RL approaches and their relation to intrinsically motivated learning and the quest for autonomous open-ended agents. Link: arxiv.org/pdf/2012.09830.pdf.
- Epidemiology and RL **Colas, C.**, Hejblum, B., Rouillon, S., Thiébaud, R., Oudeyer, P-Y., Moulin-Frier, C. & Prague, M. (2020). *EpidemiOptim: A Toolbox for the Optimization of Control Policies in Epidemiological Models*. Accepted to **JAIR**. General software library developed in collaboration with epidemiologists to facilitate the design and comparisons of epidemiological models and automatic intervention strategies to fight epidemics. Link: arxiv.org/pdf/2010.04452.pdf.
- RL Akakzia A., **Colas, C.**, Oudeyer, P-Y., Chetouani, M. & Sigaud, O. (2020). *Grounding Language to Autonomously-Acquired Skills via Goal Generation*. Accepted at **ICLR 2021**. An intrinsically motivated agents that builds its own curriculum to solve complex stacking tasks autonomously. Link: arxiv.org/pdf/2006.07185.pdf. Equal contributions of the two first authors.
- RL **Colas, C.**, Akakzia A., Oudeyer, P-Y., Chetouani, M. & Sigaud, O. (2020). *Language-Conditioned Goal Generation: a New Approach to Language Grounding for RL*. Accepted at **LaReL workshop, ICLR 2020**, 2nd best paper. A new model that turns linguistic descriptions into concrete goal embeddings for agents to target. This enables efficient generalization, and behavioral diversity, as several goals can be sampled for a given linguistic description. Link: arxiv.org/pdf/2006.07043.pdf.
- Evolutionary Algorithms **Colas, C.**, Huizinga, J., Madhavan, V., & Clune, J. (2020). *Scaling MAP-Elites to Deep Neuroevolution*. Accepted at **GECCO 2020**. Scaling of the most popular Quality-Diversity algorithm to the era of deep neural networks. New problems can be solved (hard exploration problems, high-dimensional behavioral adaptation). Link: arxiv.org/pdf/2003.01825.pdf.
- RL **Colas, C.**, Karch, T., Lair, N., Dussoux, J. M., Moulin-Frier, C., Dominey, PF. & Oudeyer, P-Y. (2020). *Language as a Cognitive Tool to Imagine Goals in Curiosity-Driven Exploration*. Accepted at **NeurIPS 2020**. The first autotelic agent using language as a cognitive tool to support the imagination of goals. Is currently leading to several PhD and postdoc projects in the lab. Link: arxiv.org/pdf/2002.09253.pdf.

- RL Colas, C., Sigaud, O. & Oudeyer, P-Y. (2018). *CURIIOUS: Intrinsically Motivated Modular Multi-Goal Reinforcement Learning*. Accepted at **ICML 2019**. The first autotelic agents based on state-of-the-art deep reinforcement learning methods. It uses automatic curriculum learning to craft its own learning trajectory learn to target multiple goals involving multiple types of affordances. Link: arxiv.org/pdf/1810.06284.pdf.
- RL Colas, C., Sigaud, O. & Oudeyer, P-Y. (2018). *GEP-PG: Decoupling Exploration and Exploitation in Deep Reinforcement Learning Algorithms*. Accepted at **ICML 2018**. First steps to merge developmental robotics autotelic methods with deep reinforcement learning. An intrinsically motivated exploration helps bootstrap a standard Deep RL algorithm. This led to multiple works on decoupling exploration and exploitation in RL. Link: arxiv.org/pdf/1802.05054.pdf.

Publications (peer-reviewed, second author)

- RL Portelas, R., Colas, C., Weng, L., Hofmann, K. & Oudeyer, P-Y. (2020) *Automatic Curriculum Learning For Deep RL: A Short Survey*. Accepted at **IJCAI 2020**. A useful survey and framework to think about automatic curriculum learning methods in deep RL. Link: arxiv.org/pdf/2003.04664.pdf.
- RL Portelas, R., Colas, C., Hofmann, K. & Oudeyer, P-Y. (2019). *Teacher Algorithms for Curriculum Learning of Deep RL in Continuously Parameterized Environments*. Accepted at **CoRL 2019**. A novel automatic curriculum learning method to shape agents learning trajectory in complex domains. Link: arxiv.org/pdf/1910.07224.pdf.
- RL Fournier P., Colas, C., Chetouani, M. & Sigaud, O. (2019). *CLIC: Curriculum Learning and Imitation for feature Control in non-rewarding environments*. Accepted at **IEEE Transactions on Cognitive and Developmental Systems**. A discrete variant of the CURIIOUS algorithm that integrates natural demonstrations. Link: arxiv.org/pdf/1901.09720.pdf.
- BCI Ortega, P., Colas, C. & Faisal, AA. (2018). *Compact Convolutional Neural Networks for Multi-Class, Personalised, Closed-Loop EEG-BCI*. In 2018 7th **IEEE International Conference on Biomedical Robotics and Biomechatronics (Biorob)** (pp. 136-141). The first BCI to consider CNN implementations to allow disabled people to control machines. Link: ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8487644

Publications (preprints or in review)

- RL Sigaud, O., Caselles-Dupré, H., Colas, C., Akazia, A., Oudeyer, P-Y. & Chetouani, M. (2021). *Towards Teachable Autonomous Agents*. **In review**. An opinion paper on the need for agents that are both intrinsically motivated and interactive (teachable). Link: arxiv.org/pdf/2105.11977.pdf.
- Stats for RL Colas, C., Sigaud, O. & Oudeyer, P-Y. (2019). *A Hitchhiker's Guide to Statistical Comparisons of Reinforcement Learning Algorithms*. A useful comparative study of statistical methods to meaningfully compare RL algorithms, and associated guidelines. Link: arxiv.org/pdf/1904.06979.pdf.
- Stats for RL Colas, C., Sigaud, O. & Oudeyer, P-Y. (2018). *How Many Random Seeds? Statistical Power Analysis in Deep Reinforcement Learning Experiments*. A discussion of the lack of statistical testing in the comparison of RL algorithms. Link: arxiv.org/pdf/1806.08295.pdf.

Non-scientific publications

- Blog post *Language as a Cognitive Tool: Dall-E, Humans and Vygotskian RL Agents*. March 2021. Link: developmentalsystems.org/language_as_cognitive_tool_vygotskian_rl.
- Blog post *Intrinsically Motivated Modular Multi-Goal RL*. March 2020. Link: developmentalsystems.org/curious_intrinsically_motivated_multi_modular_goal_rl.
- Blog post *How Many Random Seeds?* February 2020. Link: developmentalsystems.org/how_many_random_seeds.
- Blog post *Bootstrapping Deep RL with Population-Based Diversity Search*. February 2020. Link: developmentalsystems.org/bootstrapping_rl_with_diversity.

Technological Development

- EpidemiOptim Demo Online demonstration of a pre-trained lockdown policy in the context of simulated COVID19 epidemics. epidemioptim.bordeaux.inria.fr.
- EpidemiOptim library Library interfacing optimization algorithms with models of epidemic propagation. Epidemiological models are wrapped in OpenAI Gym interfaces, making them readily compatible with state-of-the-art optimization algorithms. github.com/flowersteam/epidemioptim.
- ME-ES Software of the ME-ES architecture. github.com/uber-research/Map-Elites-Evolutionary.
- Playground RL learning benchmark. Designed to facilitate the study of systematic generalization in language-conditioned RL architectures. Easy to extend to more objects, more interactions and more complex language. github.com/flowersteam/playground_env.
- Imagine Software of the IMAGINE architecture. github.com/flowersteam/imagine.
- Curious Software of the CURIOUS architecture. github.com/flowersteam/curious.
- GEP-PG Software of the GEP-PG architecture. github.com/flowersteam/geppg.
- RL stats Library providing easy-to-use tools to compare the performance of RL algorithms. Allows the replication of the experiments from *A Hitchhiker's Guide to Statistical Comparisons of Reinforcement Learning Algorithms*. github.com/flowersteam/rl-difference-testing.

Communications

- PhD Defense *Towards Vygotskian Autotelic Learning: Learning Skills with Language, Goals and Intrinsically Motivated Deep Reinforcement Learning*. June 2021 (online). Link: youtube.com/watch?v=x4vS557rhAM.
- Invited Talk EpidemiOptim: A Toolbox for the Optimization of Control Policies in Epidemiological Models. DeepMind Seminar, January 2020 (online).
- Conference Talk *Scaling MAP-Elites to Deep Neuroevolution*. Accepted at GECCO 2020. GECCO conference, July 2020 (online). Link: youtube.com/watch?v=m2peevXlgKY.
- Conference Talk *Language as a Cognitive Tool to Imagine Goals in Curiosity-Driven Exploration*. NeurIPS conference, December 2020 (online). Link: slideslive.com/38937386/language-as-a-cognitive-tool-to-imagine-goals-in-curiosity-driven-exploration?ref=speaker-28788-popular.
- Conference Talk *CURIOUS: Intrinsically Motivated Modular Multi-Goal Reinforcement Learning*. ICML conference, Long Beach CA (US), June 2019. Link: youtube.videoken.com/embed/v-W4JSWUX28?tocitem=24.
- Conference Talk *GEP-PG: Decoupling Exploration and Exploitation in Deep Reinforcement Learning Algorithms*. ICML conference; Stockholm (SW), June 2018. Link: youtu.be/MK-oAqHjdmg?t=2080.

Grants & Awards

- PhD Fellowship 3 years (2018-2021). Co-funded by INRIA and DGA (Direction Général de l'Armement, FR). 59k€ each.
- Thesis Award PhD Thesis Award 2022 from the French AI Association (AFIA).
- MSCA Postdoctoral Fellowship Marie Skłodowska-Curie Postdoctoral Fellowship for 3 years (2022-2025). Obtained for the project *Help Me Grow: Artificial Cognitive Development via Human-Agent Interactions Supported by New Interactive, Intrinsically Motivated Program Synthesis Methods*. 273k€.
- Phd Thesis Award Award for the Best PhD Thesis in France (2022) from the French Association for AI (AFIA). Prize: 1,000€.
- Corr Bayen Young Researcher Honorary Mention (2nd rank) for the 2022 European Corr Bayen Young Researcher Award in computer science.
- Honorary Mention

Supervision Experience

- Feb-Aug 2021 I supervised two 2nd year master student from Univ Paris-Sorbonne (Paris, FR). With one of them, we worked on a new benchmark and dataset to train scene captioners to enhance cutting-edge autotelic reinforcement learning algorithms (to be released soon). With the other, we worked on the addition of minimal social interventions to help autotelic agents explore in a block manipulation domain (publication submitted for review).
- Feb-June 2020 I supervised two bachelor students from Ecole de Cognitive (Bordeaux, FR). I mentored them in their project on the parallels between cognitive science and recent developments in autonomous AI systems.
- Feb-Aug, 2018 I supervised a 2nd year master student from Ecole Normale Supérieure (Rennes, FR). We worked on coupling curiosity mechanisms with model-based reinforcement learning.

■ Misc Training & Qualifications

- Programming Languages Python (proficient), Matlab (proficient), LaTeX (proficient), Processing (intermediary), Arduino-C++ (beginner).
- Languages French (native), English (fluent, 1 year in the UK, 4 months in the US), Spanish (beginner).