

Alexander Meulemans

alexandermeulemans.com, [Linked-in](#), [Github](#), [Google Scholar](#)

Research interests and expertise

At the interface of machine learning and theoretical neuroscience, my research focuses on (i) reverse-engineering in-context learning in transformer models, (ii) making reinforcement learning more sample efficient by introducing model-based credit assignment techniques for learning policies grounded in causality and (iii) creating new theories for learning in the brain by bridging optimal control with learning, leading to novel learning algorithms for deep and recurrent neural networks that alleviate important drawbacks of current neural network training methods. My research was awarded several spotlight and oral presentations at the top machine learning conferences, and I have ongoing collaborations with among others João Sacramento (ETH Zurich), Johannes von Oswald (Google Research), Greg Wayne (Google DeepMind), Nathaniel Daw (Princeton), Rafal Bogacz (Oxford) and Angelika Steger (ETH Zurich) on projects involving in-context learning in transformers, model-based credit assignment in reinforcement learning and methods for bayesian learning in the brain. To get hands-on experience in training sota transformer models, I engaged in an internship at Microsoft Research Cambridge, focusing on combining large language models with knowledge bases. My research interests include in-context learning, reinforcement learning, causality, theoretical neuroscience, optimal control, sequence learning, bilevel optimization, meta learning, and trustworthy AI.

Education

October 2019 - present	ETH Zürich Department of Computer Science – Ph.D. candidate <i>Switzerland</i> <ul style="list-style-type: none">• Extensive experience in designing new theories and algorithms, proving mathematical theorems, and scientific programming in Python using JAX, PyTorch, Numpy, and other relevant libraries.• Average grade of 98.6% on attended courses (neural network theory, causality, and neuroscience).• Supervised by Professor Angelika Steger• Anticipated graduation date: March 2024
2018 - 2019	ETH Zürich – Exchange program M.Sc. in Mathematical Engineering <i>Switzerland</i> <ul style="list-style-type: none">• Average grade: 94.4%.• Advanced courses in machine learning, deep learning and neuroinformatics.• Master's thesis 'Towards a mathematical understanding of biologically plausible learning methods for deep learning', supervised by Professor Benjamin Grewe and Professor Johan Suykens (Grade: 95%).
2017 - 2019	KU Leuven – M.Sc. in Mathematical Engineering <i>Belgium</i> <ul style="list-style-type: none">• Degree: Summa Cum Laude with congratulations from the Board of Examiners (average grade: 92%, top 1%).• Advanced engineering courses in machine learning, numerical optimization, control theory, signal processing, and scientific programming.
2014 - 2017	KU Leuven – B.Sc. in Engineering Sciences <i>Belgium</i> <ul style="list-style-type: none">• Degree: Summa Cum Laude (average grade: 86.25 %, top 2%).• Core engineering courses (Mathematics, Mechanics, Computer Science, etc.) built a solid analytical basis to solve (technical) problems of all kinds. Specialization in Electrical and Mechanical Engineering.
2015 - 2016	Luca School of Arts - Courses in Bachelor of Music <i>Belgium</i> <ul style="list-style-type: none">• Average: 84.44% (27 ECTS).• Main Instrument: viola.• Practical courses in viola, orchestra, chamber music, and music history.

Research Experience

October 2019 - present	ETH Zürich Department of Computer Science – Ph.D. candidate <i>Switzerland</i>
2020 - 2022	Zurich AI Alignment reading club – Co-organizer <i>Switzerland</i> <ul style="list-style-type: none">• I co-organized a bi-weekly discussion group on recent advances in the research field of AI safety. Inspired by the discussions, we so far published a paper on impact regularizers and a blog post on scaling laws for generalization in RL, and are now working on a new research project related to AI safety.
2017 - 2018	KU Leuven – Teaching Assistant for Applied Linear Algebra <i>Belgium</i> <ul style="list-style-type: none">• Teaching and organizing exercise sessions for 'Applied Linear Algebra' to engineering bachelor students.
2016 - 2018	KU Leuven – Research Honours Project <i>Belgium</i> <ul style="list-style-type: none">• Extracurricular research program of 18 ECTS on developing a sensitivity analysis framework for a patient-specific growth and remodeling model of an artery, programmed in Matlab and Abaqus.
August - September 2017	Reilly Lab Trinity College Dublin – Neural Engineering Research Intern <i>Ireland</i> <ul style="list-style-type: none">• Research on laying the foundation for using machine learning on neuroimaging data for diagnosing Dystonia.• Programming in Matlab and Python with machine learning toolboxes such as PRoNTo and Scikit-learn.
July - August 2016	KU Leuven – Software Engineering Intern <i>Belgium</i> <ul style="list-style-type: none">• Participating in a software engineering team for developing a graphical and computational environment for modeling 3D dynamical structures for educational purposes.• Object-oriented scientific programming in Python.

Industrial Experience

- June - September 2023 **Microsoft Research Cambridge - Researcher Intern** *UK*
- Research on distilling, compressing, and finetuning Large Language Models
 - Research on leveraging LLMs for automatic knowledge base construction
 - Working in a large team on a centralized code repository with continuous integration and various other quality assurance mechanisms
- July - August 2018 **Bain & Company – Associate Consultant Intern** *Belgium*
- Working as a full-time member of a Bain strategic consultancy case team.
 - Gaining detailed experience in efficient communication, business strategy, and project management.

Extra-Curricular Experience

- 2017 - 2019 **MUN Society Belgium – Member** *Belgium*
- Participating in the most competitive Model United Nations (MUN) competitions over the world.
 - Engaging in extensive training on public speaking, negotiating, debating, leadership, critical analysis, and technical writing from top diplomats, industry experts, and renowned professionals.
- 2018 - 2019 **Music for Parkinson – Founder and Musician** *Belgium*
- I founded the ‘Music for Parkinson’ initiative, a benefit concert in collaboration with the Demoucelle Parkinson Charity, and organized and performed its [first instance](#).
 - Experience in budgeting, and musical performing on a professional level.
- 2016 - 2019 **Altelier – Viola teacher** *Belgium*
- Preparing and giving viola lessons to children of various ages at Alteliers summer masterclasses.
- 2016 - 2017 **VTK Student board – Coordinator Orientation First Bachelor Students** *Belgium*
- Supervising and organizing all the activities for first-year bachelor students at the Faculty of Engineering Sciences at KU Leuven.
- 2012 - 2017 **Sport Flanders – Waterski & Wakeboard instructor** *Belgium, Italy*
- Teaching children and young adults how to water ski or wakeboard during summer camps.

Awards, Prizes & Recognition (Academic)

- 2023 **37th Conference on Neural Information Processing Systems - Spotlight presentation**
- Awarded to the 3% top paper submissions
- 2022 **36th Conference on Neural Information Processing Systems - Oral presentation & Award nomination**
- Awarded to the 0.5% top paper submissions
- 2021 **35th Conference on Neural Information Processing Systems - Spotlight presentation**
- Awarded to the 3% top paper submissions
- 2020 **34th Conference on Neural Information Processing Systems - Spotlight presentation**
- Awarded to the 3% top paper submissions
- 2015 **KU Leuven - Best Student Award**
- Awarded to the 10 best students of the first bachelor of Engineering Sciences (600+ students).
- 2015 **KU Leuven - Best Engineering Project**
- As the elected leader of a team of 6 multi-disciplined engineers, the jury of professors and industry experts awarded us the first prize for our electrical hand prosthesis (50 other participating groups).

Awards, Prizes & Recognition (Other)

- 2018, 2019 **London International Model United Nations – Diplomacy Award (x2)**
- Awarded to the best public speaker, negotiator, and diplomat of the committee (70 people) at the largest Model United Nations conference in Europe.
- 2018 **Harvard University – Distinguished Large Delegation Award**
- Awarded to the second-best delegation (out of +50 delegations) in terms of public speaking, negotiating and leadership, at the Harvard Model United Nations conference, the ‘Olympic games’ of Model United Nations.
- 2014 **City of Lier – City Medal of Arts**
- Awarded to the best music students in the city of Lier.
- 2014 **St. Gummarus College Lier – Prize of natural sciences**
- Awarded to the most promising student in natural sciences of all graduating students (+300 people).

Publications (Google Scholar: 152 citations; h-index 6; i10-index 5)

2023 (first author)	A Meulemans* , S Schug*, S Kobayashi*, N Daw, G Wayne - Would I have gotten that reward? Long-term credit assignment by counterfactual contribution analysis <i>NeurIPS 2023 (spotlight presentation)</i> (* equal contribution)
2022 (first author)	A Meulemans* , N Zucchet*, S Kobayashi*, J von Oswald, J Sacramento - The least-control principle for learning at equilibrium - Accepted at <i>NeurIPS 2022 (award nomination)</i> (* equal contribution)
2022 (first author)	A Meulemans* , MT Farinha*, Maria Cervera*, J Sacramento, BF Grewe - Minimizing Control for Credit Assignment with Strong Feedback - <i>ICML 2022 (spotlight presentation)</i> (* equal contribution)
2021 (first author)	A Meulemans* , MT Farinha*, JG Ordóñez, PV Aceituno, J Sacramento, BF Grewe - Credit assignment in neural networks through Deep Feedback Control - <i>NeurIPS 2021 (spotlight presentation)</i>
2021 (first author)	D Lindner*, K Matoba*, A Meulemans* - Challenges for using impact regularizers to avoid negative side effects. <i>SafeAI - AAAI 2021</i> (* equal contribution)
2020 (first author)	A Meulemans , F Carzaniga, J Suykens, J Sacramento, BF Grewe - A Theoretical Framework for Target Propagation - <i>NeurIPS 2020 (spotlight presentation)</i>
2021 (second author)	B Ehret*, C Henning*, MR Cervera*, A Meulemans , J von Oswald, BF Grewe - Continual learning in recurrent neural networks - <i>ICLR 2021</i> (* equal contribution)
2021 (second author)	J von Oswald*, S Kobayashi*, A Meulemans , C Henning, BF Grewe, J Sacramento - Neural networks with late-phase weights - <i>ICLR 2021</i> (* equal contribution)

Invited talks (selection)

2023 June	University of Cambridge - Control group The least-control principle for local learning at equilibrium	UK
2023 March	COSYNE conference The least-control principle: learning with top-down feedback as optimal control	Canada
2022 September	MILA - LINC Lab (prof. Blake Richards) The least-control principle for learning at equilibrium	Canada
2022 January	EPFL, Laboratory of Computational Neuroscience (prof. Gerstner) Credit assignment in neural networks through deep feedback control	Virtual
2021 November	University of Bern, Senn lab Credit assignment in neural networks through deep feedback control	Switzerland
2021 September	University of Sheffield, ML seminars Credit assignment in neural networks through deep feedback control [recording]	Virtual
2021 January	Amazon Web Services, Lunch & Learn An Introduction to Artificial Intelligence	Virtual

Conference abstracts

2023 March	COSYNE The least-control principle for local learning at equilibrium	Canada
2022 April	Cold Spring Harbor Laboratories - From Neuroscience to Artificially Intelligent Systems The least-control principle for learning	New York
2022 March	COSYNE Principled credit assignment with strong feedback through deep feedback control	Portugal
2021 October	Champalimaud Research Symposium Credit assignment in neural networks through deep feedback control	Portugal
2021 September	ACAIN Credit assignment in neural networks through deep feedback control	United Kingdom

Additional Information

Language skills:	Dutch: Native	English: Fluent	French: Intermediate	German: Basic
Coding:	Python (mainly PyTorch, JAX, and Numpy), Matlab & Simulink, LaTeX, Github: meulemansalex .			
Soft skills:	Numerous music performances made me comfortable with large audiences. Professional training with MUN Society Belgium fine-tuned my public speaking, debating, and efficient communication skills.			
Personal interests:	Viola, guitar, piano, chamber music, folk band, waterskiing, skiing, self-development, climbing, homemade pizza.			