Artemy Kolchinsky

Universal Biology Institute, University of Tokyo

CONTACT

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EDUCATION

Indiana University (Bloomington, IN, USA), 2015
Ph.D. in Informatics (focus in Complex Systems), Minor in Cognitive Science
Thesis: "Measuring Scales: Integration and Modularity in Complex Systems"
Committee: Luis M. Rocha (chair), Yong-Yeol Ahn, Randall Beer, Alessandro Flammini, Olaf Sporns

New York University (New York, NY, USA), 2004
B.A. Magna Cum Laude, Individualized Study (concentration in Complex Systems)

ACADEMIC POSITIONS

Universitat Pompeu Fabra (Barcelona, Spain), June 2023-
Marie Curie postdoctoral fellow

University of Tokyo (Tokyo, Japan), Jan 2022-May 2023
Project researcher at the Universal Biology Institute

Santa Fe Institute (Santa Fe, NM, USA), Dec 2015-Dec 2021
Postdoctoral fellow with postdoctoral advisor David H. Wolpert

Instituto Gulbenkian de Ciência (Oeiras, Portugal), 2009-2010 and Summer 2008/2011/2012
Visiting researcher at FLAD Computational Biology Collaboratorium

Indiana University (Bloomington, IN, USA), Sep 2011-May 2015
Research assistant with Ph.D. advisor Luis M. Rocha

INDUSTRY

LinkedIn Corporation (Mountain View, CA, USA), Summer 2014
Data science internship. Supervisor: Mathieu Bastian

PUBLICATIONS

A. Kolchinsky, "Generalized Zurek's bound on the cost of an individual classical or quantum computation", *Physical Review E*, 2023. pdf

M. Aguilera and **A. Kolchinsky**, "Quantifying higher-order entropy production in organized nonequilibrium states", *Proceedings of the ALIFE 2023*, 2023. pdf

A. Kolchinsky, "Generalized Zurek's bound on the cost of an individual classical or quantum computation", *Physical Review E*, 2023. pdf

N. Ohga, S. Ito, **A. Kolchinsky**, "Thermodynamic bound on the asymmetry of cross-correlations", *Physical Review Letters*, 2023. (*Editors' Suggestion*; *Featured in Physics*) pdf

K. Yoshimura, **A. Kolchinsky**, A. Dechant, S. Ito, "Housekeeping and excess entropy production for general nonlinear dynamics", *Physical Review Research*, 2023. pdf

F.C. Sheldon, **A. Kolchinsky**, F. Caravelli, "Computational capacity of LRC, memristive, and hybrid reservoirs", *Physical Review E*, 2022. pdf

A. Kolchinsky, "A Novel Approach to the Partial Information Decomposition", *Entropy*, 2022. pdf code

A. Kolchinsky and D.H. Wolpert, "Dependence of integrated, instantaneous, and fluctuating entropy production on the initial state in quantum and classical processes", *Physical Review E*, 2021. pdf

A. Kolchinsky and D.H. Wolpert, "Work, entropy production, and thermodynamics of information under protocol constraints", *Physical Review X*, 2021. pdf

A. Kolchinsky and D.H. Wolpert, "Entropy production given constraints on the energy functions", *Physical Review E*, 2021. pdf

A. Kolchinsky and D.H. Wolpert, "Thermodynamic costs of Turing Machines", *Physical Review Research*, 2020. pdf

D.H. Wolpert and **A. Kolchinsky**, "The thermodynamics of computing with circuits", *New Journal of Physics*, 2020. pdf

A. Kolchinsky and B. Corominas-Murtra, "Decomposing information into copying versus transformation", *Royal Society Interface*, 2020. pdf

A.M. Saxe, Y. Bansal, J. Dapello, M. Advani, **A. Kolchinsky**, B.D. Tracey, D.D. Cox, "On the information bottleneck theory of deep learning", *Journal of Statistical Mechanics*, 2019. pdf code

A. Kolchinsky, B.D. Tracey, D.H. Wolpert, "Nonlinear information bottleneck", *Entropy*, 2019. pdf (*Entropy 2021 Best Paper Award*)

A. Berdahl, C. Brelsford, C. De Bacco, M. Dumas, V. Ferdinand, J.A. Grochow, L. Hébert-Dufresne, Y. Kallus, C.P. Kempes, **A. Kolchinsky**, D. B. Larremore, E. Libby, E.A. Power, C.A. Stern, B.D.Tracey, "Dynamics of beneficial epidemics", *Scientific Reports*, 2019. pdf

E.A. Hobson, V. Ferdinand, **A. Kolchinsky**, J. Garland, "Rethinking animal social complexity measures with the help of complex systems concepts", *Animal Behaviour*, 2019. pdf

A. Kolchinsky, B.D. Tracey, S. Van Kuyk, "Caveats for information bottleneck in deterministic scenarios", *International Conf on Learning Representations (ICLR)*, 2019. pdf code

D.H. Wolpert, **A. Kolchinsky**, J.A. Owen, "A space–time tradeoff for implementing a function with master equation dynamics", *Nature Communications*, 2019. pdf

A. Avena-Koenigsberger, X. Yan, **A. Kolchinsky**, M. van den Heuvel, P. Hagmann, O. Sporns, "A spectrum of routing strategies for brain networks", *PLoS Computational Biology*, 2019. pdf

J.A. Owen, **A. Kolchinsky**, D.H. Wolpert, "Number of hidden states needed to physically implement a given conditional distribution", *New Journal of Physics*, 2019. (correction) pdf

A. Kolchinsky and D.H. Wolpert, "Semantic information, autonomous agency, and nonequilibrium statistical physics", *Royal Society Interface Focus*, 2018. pdf code

A.M. Saxe, Y. Bansal, J. Dapello, M. Advani, **A. Kolchinsky**, B.D. Tracey, D.D. Cox, "On the information bottleneck theory of deep learning", *International Conf on Learning Representations (ICLR)*, 2018. pdf code

A. Kolchinsky, N. Dhande, K. Park, Y.Y. Ahn, "The Minor Fall, the Major Lift: Inferring emotional valence of musical chords through lyrics", *Royal Society Open Science*, 2017. pdf data code

A. Kolchinsky, D.H. Wolpert, "Dependence of dissipation on the initial distribution over states", *Journal of Statistical Mechanics*, 2017. pdf

A. Kolchinsky, B.D. Tracey, "Estimating mixture entropy with pairwise distances", *Entropy*, 2017. (correction) pdf code

A. Kolchinsky, A.J. Gates, L.M. Rocha, "Modularity and the spread of perturbations in complex dynamical systems," *Physical Review E*, 2015. pdf code

A. Kolchinsky, A. Lourenço, H. Wu, L. Li, L.M. Rocha, "Extraction of pharmacokinetic evidence of drug-drug interactions from the literature," *PLOS One*, 2015. pdf

A. Kolchinsky, M.P. van den Heuvel, A. Griffa, P. Hagmann, L.M. Rocha, O. Sporns, J. Goñi, "Multi-scale integration and predictability in resting state brain activity," *Frontiers in Neuroinformatics*, 2014. pdf

A. Rossi, F.J. Parada, **A. Kolchinsky**, A. Puce, "Neural correlates of apparent motion perception of impoverished facial stimuli I: A comparison of ERP and ERSP activity," *NeuroImage*, 2014. pdf

A. Kolchinsky, A. Lourenço, L. Li, L.M. Rocha, "Evaluation of linear classifiers on articles containing pharmacokinetic evidence of drug-drug interactions," *Proc Pacific Symposium on Biocomputing*, 2013. pdf

A. Kolchinsky and L.M. Rocha, "Prediction and modularity in dynamical systems," *Proc of European Conf. on the Synthesis and Simulation of Living Systems (ECAL)*, 2011. pdf

A. Kolchinsky, A. Abi-Haidar, J. Kaur, A.A. Hamed, L.M. Rocha, "Classification of protein-protein interaction full-text documents using text and citation network features," *IEEE/ACM Transactions on Computational*

Biology and Bioinformatics, 2010. pdf

POPULAR SCIENCE	**A. Kolchinsky**, "The cost of sending a bit across a living cell", *Physics Magazine*, 2023. link
PREPRINTS	P.M. Riechers, C. Gupta, **A. Kolchinsky**, M. Gu, "Thermodynamically ideal quantum-state inputs to any device", arXiv:2305.00616, 2023. arxiv

P.M. Riechers, C. Gupta, **A. Kolchinsky**, M. Gu, "Thermodynamically ideal quantum-state inputs to any device", arXiv:2305.00616, 2023. arxiv

D.R. Sowinski, J. Carroll-Nellenback, R.N. Markwick, J. Piñero, M. Gleiser, **A. Kolchinsky**, G. Ghoshal, A. Frank, "Semantic Information in a model of Resource Gathering Agents", arXiv:2304.03286, 2023. arxiv

A. Kolchinsky, N. Ohga, S. Ito, "Thermodynamic bound on spectral perturbations", arXiv:2304.01714, 2023. arxiv

J. Piñero, R. Solé, **A. Kolchinsky**, "Universal bounds on optimization of free energy harvesting", arXiv:2303.04975, 2023. arxiv

A. Kolchinsky, A. Dechant, K. Yoshimura, S. Ito, "Information geometry of excess and housekeeping entropy production", arXiv:2206.14599, 2022. arxiv

A. Kolchinsky, "A thermodynamic threshold for Darwinian evolution", arXiv:2112.02809, 2021. arxiv

C. Gokler, **A. Kolchinsky**, Z. Liu, I. Marvian , P. Shor, O. Shtanko, K. Thompson, D. Wolpert, S. Lloyd, "When is a bit worth much more than $kT \ln 2$?", arXiv:1705.09598, 2017. arxiv

A. Kolchinsky, I. Marvian, C. Gokler, Z. Liu, P. Shor, O. Shtanko, K. Thompson, D. Wolpert, S. Lloyd, "Maximizing free energy gain", arXiv:1705.00041, 2017. arxiv

INVITED TALKS

6/2022 - *Evolution of complexity from the statistical physics perspective*, Yerevan Physics Inst., Armenia (virtual)
"Thermodynamics of Darwinian evolution"

5/2022 - *Yagami Statistical Physics Seminar*, Keio University, Japan (virtual)
"Thermodynamics under protocol constraints"

5/2022 - *Workshop on Stochastic Thermodynamics III*, University of Tokyo, Japan (virtual)
"The algorithmic cost of a single classical or quantum computation"

4/2022 - *Cross Labs Workshop: Is AI Extending the Mind?*, Cross Labs, Japan (virtual)
"Autonomous agents and semantic information"

2/2022 - *Physics Department Colloquium Series*, University of Rochester, NY, USA (virtual)
"A thermodynamic threshold for Darwinian evolution"

12/2021 - *Universal Biology Institute Seminar Series*, University of Tokyo, Tokyo (virtual)
"A thermodynamic threshold for Darwinian evolution"

02/2021 - *Origins of Life: The Possible and the Actual* workshop, Santa Fe Institute, NM, USA
"Fundamental thermodynamic constraints and trade-offs in origin of life"

7/2020 - *ICTP Seminar Series*, Abdus Salam International Center for Theoretical Physics, Trieste, Italy (virtual)
"Bounds on entropy production and thermodynamics of information under protocol constraints"

2/2020 - *AI Seminar Series*, Information Sciences Institute, Los Angeles, CA, USA
"Machine Learning through the information bottleneck"

7/2019 - *ISTI Seminar Series*, Los Alamos National Lab, Los Alamos, NM, USA
"Machine Learning through the information bottleneck"

6/2018 - *Connectomics Lecture Series*, Universidad Diego Portales, Santiago, Chile
"Machine learning, deep neural networks, and the brain"

4/2018 - *Meeting of the Society for the Neural Control of Movement*, Santa Fe, NM, USA
"Machine learning, deep neural networks, and the brain"

4/2018 - *SITE Santa Fe* (contemporary art museum), Santa Fe, NM, USA
"Life, entropy, and the 2nd law of thermodynamics"

11/2017 - Seoul National University, South Korea
"Science at the Santa Fe Institute" (w/ V. Ferdinand)

8/2017 - *Thermodynamics & Computation: Towards a New Synthesis*, Santa Fe Institute, NM, USA
"Statistical physics of Turing Machines" (w/ D.H. Wolpert)

10/2016 - *Statistical Physics, Information Processing and Biology*, Santa Fe Institute, NM, USA
"Dependence of dissipation on the initial distribution" (w/ D.H. Wolpert)

2/2016 - Information Sciences Institute, Los Angeles, CA, USA
"Multi-scale integration & modularity in complex systems"

AWARDS & FELLOWSHIPS	2022 - Marie Curie Individual Fellowship (HORIZON-MSCA-2021-PF-01) "NETOLIFE: Nonequilibrium thermodynamics of the origin of life" 2012 - 2013 - Lilly Graduate Fellowship, Biocomplexity Institute, Indiana University, Bloomington, IN 2007 - 2009 - Eli Lilly Fellowship, Indiana University, Bloomington, IN, 2004 - Dean's List Gallatin School, New York University, NY
GRANTS	2022 - John Templeton Foundation (62417), $627,227, Co-PI "Information Architectures That Enable Life: The Emergence Of Meaning" 2019 - Foundational Questions Institute (FQXi-RFP-IPW-1912), $118,100, Co-Investigator (PI: David Wolpert) "The role of constraints in the thermodynamics of intelligence" 2016 - Foundational Questions Institute (FQXi-RFP-1622), $128,319, Co-Investigator (PI: David Wolpert) "Observers as self-maintaining non-equilibrium systems" 2016 - NSF INSPIRE (CHE-1648973), $999,947, co-author (PI: David Wolpert) "Tradeoffs in the Thermodynamics of Computation: A New Paradigm for Biological Information-Processing" 2016 - NSF (1620462), $770,000, co-author (PI: David Wolpert) "Information Networks and the Evolution of Social Organizations"
TEACHING	**Online courses** 2018 - "Fundamentals of machine learning" (w/ B.D. Tracey), Complexity Explorer from the Santa Fe Institute Designed and delivered a 12-part online course on basics of machine learning [link] **Workshops, lectures, and tutorials** 6/2019 - Santa Fe Institute Complex Systems Summer School, NM, USA Two lecture series on machine learning and its research frontiers 3/2019 - Santa Fe Institute, NM, USA Tutorial on "Machine learning with TensorFlow" 6/2017, 6/2018 - Santa Fe Institute, NM, USA Tutorial on introduction to programming and data analysis in Python (w/ V. Ferdinand) 11/2017 - Seoul National University, Seoul, South Korea Week-long workshop on "Thermodynamics, evolution, and inference through the lens of information theory" (w/ V. Ferdinand) 11/2017 - ACtioN/Trustee Meeting, Santa Fe Institute, NM, USA Lecture on "Machine learning: A guide for the perplexed" (w/ B. D. Tracey) 5/2010 - Instituto Gulbenkian de Ciência, Oeiras, Portugal Assisted with week-long "Bayesian brain" educational module **Teaching Assistant at Indiana University, Bloomington, IN** Spring 2014 - "I400 Large-scale Social Phenomena" [link] Spring 2011 - "I201 Math and logic foundations of Informatics"

Fall 2010 - "I485 Biologically Inspired Computing" [link]
Developed and implemented a 5-part computational lab series

Fall 2008-Spring 2009 - "I210 Information Infrastructure" (Python programming)

ADVISING

Nicolas Freitas, Santa Fe Institute REU Program, Santa Fe, NM, June-August, 2018
Project: "Scaling of information in biochemical systems"

Francis Cavanna, Santa Fe Institute REU Program, Santa Fe, NM, June-August, 2017
Project: "Investigating the relationship between criticality and Landauer costs using the Ising model"

ACADEMIC SERVICE

Guest editor: *Entropy* special issue on "Thermodynamics and Information Theory of Living Systems" link

Reviewer
Physics: *New J of Physics*, *PRL*, *PRR*, *PRE*, *Frontiers in Physics*, *J of Physics A*, *Physica A*
Biology: *J R Soc Proc B*, *PLoS Comp Bio*, *Theory in the Biosciences*
Information theory and machine learning: *Entropy*, *ICLR*, *IEEE Trans on Pattern Analysis and Machine Intelligence*, *Kybernetika*, *Applied Sciences*

Other
2008-2013 - Started and ran a weekly discussion group on complexity, dynamical systems, and embodiment in cognitive science, Indiana University, Bloomington, IN link

SKILLS

Programming: Python, MATLAB, C, C++, R, Java
    machine learning with TensorFlow, web programming, databases/SQL, scalable computing

Languages: Fluency: English, Russian, Spanish / Basic: Portuguese