

Artemy Kolchinsky

- CONTACT** Santa Fe Institute
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- EDUCATION** **Indiana University**, Bloomington, IN, 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, 2004
B.A. Magna Cum Laude, Individualized Study (concentration in Complex Systems)
- ACADEMIC POSITIONS** **Santa Fe Institute**, Santa Fe, NM, Dec 2015-Present
Postdoctoral fellow. (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, 2011-2015
Research assistant with Ph.D. advisor Luis M. Rocha
- INDUSTRY** **LinkedIn Corporation**, Mountain View, CA, Summer 2014
Data science internship. Supervisor: Mathieu Bastian
- PUBLICATIONS** **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, 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, 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 Conference 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 Conference 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](#)

PREPRINTS

A. Kolchinsky, “A thermodynamic threshold for Darwinian evolution”, arXiv:2112.02809, 2021. [arxiv](#)

F.C. Sheldon, **A. Kolchinsky**, F. Caravelli, “The computational capacity of memristor reservoirs”, arXiv:2009.00112, 2020. [arxiv](#)

A. Kolchinsky, “A novel approach to multivariate redundancy and synergy”, arXiv:1908.08642, 2019. [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](#)

TALKS

Invited

5/2022 - *Workshop on Stochastic Thermodynamics III*, University of Tokyo (virtual)
T.B.D.

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

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

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

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

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

7/2019 - *ISTI Seminar Series*, Los Alamos National Lab, Los Alamos, NM
 “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
 “Machine learning, ‘deep neural networks’, and the brain”

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

11/2017 - Seoul National University
 “Science at the Santa Fe Institute” (w/ V. Ferdinand)

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

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

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

GRANTS

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 a 12-part online course on basics of machine learning [[link](#)]

Workshops, lectures, and tutorials

6/2019 - Santa Fe Institute Complex Systems Summer School, Santa Fe, NM
 Two lecture series on machine learning and its research frontiers

3/2019 - Santa Fe Institute, Santa Fe, NM
 Tutorial on “Machine learning with TensorFlow”

6/2017, 6/2018 - Santa Fe Institute, Santa Fe, NM
 Tutorial on introduction to programming and data analysis in Python (w/ V. Ferdinand)

11/2017 - Seoul National University, Seoul
 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, Santa Fe, NM
 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 ran 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 Journal of Physics*, *Physical Review Letters*, *Physical Review Research*, *Frontiers in Physics*, *Journal of Physics A*, *Physica A*.

Reviewer (biology): *J R Soc Proceedings B*, *PLoS Computational Biology*, *Theory in the Biosciences*.

Reviewer (information theory and machine learning): *Entropy*, *ICLR*, *Transactions on Pattern Analysis and Machine Intelligence*, *Kybernetika*, *Applied Sciences*.

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

**AWARDS &
FELLOWSHIPS**

2010-2015 - Affiliate of IGERT training program in “Dynamics of brain-body-environment interaction in behavior and cognition”

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

SKILLS

Programming: Python, MATLAB, C, C++, R, Java

Machine learning with Python + Keras, TensorFlow

Web programming, databases/SQL, scalable computing (Hadoop, PIG, Scala)

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