

## Artemy Kolchinsky

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<b>EDUCATION</b>	<b>Indiana University</b> , 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 <b>New York University</b> , New York, NY, 2004 B.A. Magna Cum Laude, Individualized Study (concentration in Complex Systems)	
<b>ACADEMIC POSITIONS</b>	<b>Santa Fe Institute</b> , Santa Fe, NM, Dec 2015-Present Postdoctoral fellow <b>Instituto Gulbenkian de Ciência</b> , Oeiras, Portugal, 2009-2010 and Summer 2008/2011/2012 Visiting researcher at FLAD Computational Biology Collaboratorium <b>Indiana University</b> , Bloomington, IN, 2011-2015 Research assistant with Ph.D. advisor Luis M. Rocha	
<b>INDUSTRY</b>	<b>LinkedIn Corporation</b> , Mountain View, CA, Summer 2014 Data science internship. Supervisor: Mathieu Bastian	
<b>PUBLICATIONS</b>	<b>A. Kolchinsky</b> and D.H. Wolpert, “Dependence of integrated, instantaneous, and fluctuating entropy production on the initial state in quantum and classical processes”, <i>Physical Review E</i> , 2021. <a href="#">pdf</a> <b>A. Kolchinsky</b> , D.H. Wolpert, “Work, entropy production, and thermodynamics of information under protocol constraints”, <i>Physical Review X</i> , 2021. <a href="#">pdf</a> <b>A. Kolchinsky</b> and D.H. Wolpert, “Entropy production given constraints on the energy functions”, <i>Physical Review E</i> , 2021. <a href="#">pdf</a> <b>A. Kolchinsky</b> , D.H. Wolpert, “Thermodynamic costs of Turing Machines”, <i>Physical Review Research</i> , 2020. <a href="#">pdf</a> D.H. Wolpert and <b>A. Kolchinsky</b> , “The thermodynamics of computing with circuits”, <i>New Journal of Physics</i> , 2020. <a href="#">pdf</a> <b>A. Kolchinsky</b> and B. Corominas-Murtra, “Decomposing information into copying versus transformation”, <i>Royal Society Interface</i> , 2020. <a href="#">pdf</a> A.M. Saxe, Y. Bansal, J. Dapello, M. Advani, <b>A. Kolchinsky</b> , B.D. Tracey, D.D. Cox, “On the information bottleneck theory of deep learning”, <i>Journal of Statistical Mechanics</i> , 2019. <a href="#">pdf</a> <a href="#">code</a> <b>A. Kolchinsky</b> , B.D. Tracey, D.H. Wolpert, “Nonlinear information bottleneck”, <i>Entropy</i> , 2019. <a href="#">pdf</a> ( <i>Entropy</i> 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, <b>A. Kolchinsky</b> , D. B. Larremore, E. Libby, E.A. Power, C.A. Stern, B.D. Tracey, “Dynamics of beneficial epidemics”, <i>Scientific Reports</i> , 2019. <a href="#">pdf</a> E.A. Hobson, V. Ferdinand, <b>A. Kolchinsky</b> , J. Garland, “Rethinking animal social complexity measures with the help of complex systems concepts”, <i>Animal Behaviour</i> , 2019. <a href="#">pdf</a> <b>A. Kolchinsky</b> , B.D. Tracey, S. Van Kuyk, “Caveats for information bottleneck in deterministic scenarios”, <i>International Conference on Learning Representations (ICLR)</i> , 2019. <a href="#">pdf</a> <a href="#">code</a> D.H. Wolpert, <b>A. Kolchinsky</b> , J.A. Owen, “A space–time tradeoff for implementing a function with master equation dynamics”, <i>Nature Communications</i> , 2019. <a href="#">pdf</a>	

- 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 ERSF 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

- 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  
“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 2<sup>nd</sup> 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”

### Contributed

3/2021 - *American Physical Society March Meeting* (virtual)  
 “Thermodynamics under protocol constraints” (w/ D.H. Wolpert)

6/2020 - *Stochastic thermodynamics in complex systems*, Complexity Science Hub, Vienna, Austria  
 “Entropy production & thermodynamics of information under protocol constraints”

5/2019 - *Seminar*, Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany  
 “A novel measure of multivariate redundant information”

3/2019 - *American Physical Society March Meeting*, Boston, MA  
 “Thermodynamics of Turing Machines” (w/ D.H. Wolpert)

3/2018 - *American Physical Society March Meeting*, Los Angeles, CA  
 “Thermodynamic costs, initial distributions, and Bregman divergences” (w/ D.H. Wolpert)

1/2018 - *Information theory and non-equilibrium thermodynamics beyond the Shannon-Gibbs framework*, Complexity Science Hub, Vienna, Austria  
 “Entropy in stochastic thermodynamics”

12/2017 - *Complexity, Criticality & Computation International Biannual Symposium*, University of Sydney  
 “Grounding semantic information in the dynamics of non-equilibrium systems” (w/ D.H. Wolpert)

8/2017 - *Information Engines at the Frontiers of Nanoscale Thermodynamics*, Telluride, CO  
 “Semantic information, observation and non-equilibrium systems” (w/ D.H. Wolpert)

3/2017 - *American Physical Society March Meeting*, New Orleans, LA  
 “Dependence of dissipation on the initial distribution” (w/ D.H. Wolpert)

10/2015 - *Information Theory, Ecosystems, & Schrodinger’s Paradox* workshop, Santa Fe Institute  
 “Complexity measures for spatially embedded systems”

9/2015 - *Conference on Complex Systems 2015*, Tempe, AZ  
 “Modularity and the spread of perturbations in complex dynamical systems” (w/ A.J. Gates, L.M. Rocha)  
 (awarded “Honorable Mention Paper by a Contributing Student”)

10/2013 - *Indiana Neuroimaging Symposium*, Indiana University, Bloomington, IN  
 “Information, space & structure in the human brain resting state” [poster] (w/ M.P. van den Heuvel, A. Griffa, P. Hagmann, L.M. Rocha, O. Sporns, J. Goñi)

9/2013 - *Guided Self-Organization 6 workshop, European Conf on Complex Systems*, Barcelona, Spain  
 “Modularity and dynamical timescales in Boolean Networks”

3/2013 - *MBI Rhythms and Oscillations Workshop*, Columbus, OH

“Studying differences in oscillatory synchronization with tensor-factorization” [poster] (w/ F.J. Parada, L.M. Rocha, T. Busey)

1/2013 - *Pacific Symposium on Biocomputing*, Big Island, Hawaii

“Evaluation of linear classifiers on articles containing pharmacokinetic evidence of drug-drug interactions”

12/2011 - *Network Frontier Workshop*, Northwestern University, Evanston, IL

“Prediction and modularity in dynamical systems”

4/2011 - *CISAB Animal Behavior Conference*, Indiana University, Bloomington, IN

“The Umwelt, artificial life, and evolution”

9/2010 - *Guided Self-Organization 3 work*, Indiana University, Bloomington, IN

“Identifying dynamical modules in Boolean network models”

3/2008 - *Interdisciplinary Symposium on the Mind*, University of Toronto

“The Expanded Mind: Mental expansion and the intentional stance”

## GRANTS

9/2019 - Foundational Questions Institute (FQXi), “The role of constraints in the thermodynamics of intelligence” (FQXi-RFP-IPW-1912), \$118,100, Co-Investigator

8/2016 - Foundational Questions Institute (FQXi), “Observers as self-maintaining non-equilibrium systems” (FQXi-RFP-1622), \$128,319, Co-Investigator

## TEACHING

### Invited Lectures

6/2019 - Santa Fe Institute Complex Systems Summer School, Santa Fe, NM

### Workshops

3/2019 - Santa Fe Institute, Santa Fe, NM

“Machine learning with TensorFlow”

6/2017, 6/2018 - Santa Fe Institute, Santa Fe, NM

Introduction to programming and data analysis in Python (w/ V. Ferdinand)

11/2017 - Seoul National University, Seoul

“Thermodynamics, evolution, and inference through the lens of information theory” (w/ V. Ferdinand)

11/2017 - ACTioN/Trustee Meeting, Santa Fe Institute, Santa Fe, NM

“Machine learning: A guide for the perplexed” (w/ B. D. Tracey)

### Teaching Assistant

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” [\[link\]](#)

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

Instituto Gulbenkian de Ciência, Oeiras, Portugal

Spring 2010 - “Bayesian brain” educational module

## 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