

Bryan C. Daniels

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Research Vision

I investigate collective behavior in living systems by integrating empirical data with concepts and methods from statistical physics, dynamical systems, and model selection. Working closely with broad-minded collaborators — willing and excited by the prospect of exploring new ideas and solving hard problems — I seek to discover the computational logic of adaptive collective systems.

Education

2005–2010 **Cornell University** *Ph.D., Theoretical Physics*

Dissertation: *Robustness and Evolvability in Systems Biology and Plectoneme Formation in DNA Supercoiling.*

2001–2005 **Ohio Wesleyan University** *B.A., Physics, Summa cum laude*

Academic Positions & Fellowships

2020–present **School of Complex Adaptive Systems**

Assistant Research Professor,
College of Global Futures, Arizona State University

2021–present **Julie Ann Wrigley Global Futures Laboratory**

Senior Global Futures Scientist, Arizona State University

2015–present **ASU–SFI Center for Biosocial Complex Systems**

Assistant Research Professor (2017), Postdoctoral Fellow (2015),
Arizona State University and Santa Fe Institute

2019–2020 **Berlin Institute for Advanced Study**

Fellow, College for Life Sciences

2012–2015 **Center for Complexity and Collective Computation**

Postdoctoral Fellow, University of Wisconsin–Madison

Mentors: Jessica Flack and David Krakauer

2010–2012 **Santa Fe Institute**

Postdoctoral Fellow

Mentors: Jessica Flack and David Krakauer

2005–2010 **Cornell University**

Graduate student, Laboratory of Atomic and Solid State Physics (*Advisor:* James Sethna)

2009 **Los Alamos National Laboratory**

Graduate Research Intern, Center for Nonlinear Studies (*Mentor:* Ilya Nemenman)

2006 **Indiana University**

IGERT Fellow, Cognitive Science Department (*Mentor:* Randall Beer)

Honors & Awards

- 2019 Fellowship in College for Life Sciences, Berlin Institute for Advanced Study
- 2016 Travel Award, q-bio Program Committee, sponsored by NSF
- 2016 Shirley Chan Travel Award, Div. Biological Physics, American Physical Society
- 2014 Finalist, Burroughs Wellcome Fund Career Awards at the Scientific Interface
- 2005–2007 IGERT Fellowship in Nonlinear Systems
- 2005 Phi Beta Kappa
- 2005 Rusk Prize in Physics
- 2005 Sigma Xi Research Award

Publications

- *The basis of easy controllability in Boolean networks.*
Enrico Borriello and Bryan C. Daniels.
Nature Communications **12**, 5227 (2021).
- *Innovations are disproportionately likely in the periphery of a scientific network.*
Deryc Painter, Bryan C. Daniels, and Manfred Laubichler.
Theory in Biosciences **140**, 391 (2021).
- *Quantifying the impact of network structure on speed and accuracy in collective decision-making.*
Bryan C. Daniels and Pawel Romanczuk.
Theory in Biosciences **140**, 379 (2021).
- *Quantifying dynamical high-order interdependencies from the O-information: An application to neural spiking dynamics.*
Sebastiano Stramaglia, Tomas Scagliarini, Bryan C. Daniels, and Daniele Marinazzo.
Frontiers in Physiology **11**, 595736 (2021).
- *Scaling theory of armed conflict avalanches.*
Edward D. Lee, Bryan C. Daniels, Christopher R. Myers, David C. Krakauer, and Jessica C. Flack.
Phys. Rev. E **102**, 042312 (2020).
- *Tyramine and its receptor TYR1 linked behavior QTL to reproductive physiology in honey bee workers (Apis mellifera).*
Ying Wang, Gro V. Amdam, Bryan C. Daniels, and Robert E. Page, Jr.
Journal of Insect Physiology **126**, 104093 (2020).
- *Individual and collective encoding of risk in animal groups.*
Matthew M. G. Sosna, Colin R. Twomey, Joseph Bak-Coleman, Winnie Poel, Bryan C. Daniels, Pawel Romanczuk, and Iain D. Couzin.
Proc. Natl. Acad. Sci. USA **116**, 20556 (2019).
- *Automated, predictive, and interpretable inference of Caenorhabditis elegans escape dynamics.*
Bryan C. Daniels, William S. Ryu, and Ilya Nemenman.
Proc. Natl. Acad. Sci. USA **116**, 7226 (2019).

- *Convenient Interface to Inverse Ising (ConIII): A Python 3 package for solving Ising-type maximum entropy models.*
Edward D. Lee and Bryan C. Daniels.
Journal of Open Research Software **7**, 3 (2019).
- *Network Analysis for the Digital Humanities: Principles, Problems, Extensions.*
Deryc T. Painter, Bryan C. Daniels, and Jürgen Jost.
Isis **110**, 538-554 (2019).
- *Criticality distinguishes the ensemble of biological regulatory networks.*
Bryan C. Daniels, Hyunju Kim, Douglas Moore, Siyu Zhou, Harrison Smith, Bradley Karas, Stuart A. Kauffman, and Sara I. Walker.
Phys. Rev. Lett. **121**, 138102 (2018).
- *Locating decision-making circuits in a heterogeneous neural network.*
Emerson Arehart, Tangxin Jin, and Bryan C. Daniels.
Frontiers in Applied Mathematics and Statistics **4**, 11 (2018).
- *Collective memory in macaque conflict implied by temporal scaling collapse.*
Edward D. Lee, Bryan C. Daniels, David C. Krakauer, and Jessica C. Flack.
J. Royal Society Interface **14**, 20170223 (2017).
- *Dual coding theory explains biphasic collective computation in neural decision-making.*
Bryan C. Daniels, Jessica C. Flack, and David C. Krakauer.
Frontiers in Neuroscience **11**, 313 (2017).
- *Control of finite critical behaviour in a small-scale social system.*
Bryan C. Daniels, David C. Krakauer, and Jessica C. Flack.
Nature Communications **8**, 14301 (2017).
- *Quantifying collectivity.*
Bryan C. Daniels, Christopher J. Ellison, David C. Krakauer, and Jessica C. Flack.
Current Opinion in Neurobiology **37**, 106 (2016).
- *Automated adaptive inference of dynamical phenomenological models.*
Bryan C. Daniels and Ilya Nemenman.
Nature Communications **6**, 8133 (2015).
- *Sloppiness and emergent theories in physics, biology, and beyond.*
Mark K. Transtrum, Benjamin Machta, Kevin Brown, Bryan C. Daniels, Christopher R. Myers, James P. Sethna.
J. Chem. Phys. **143**, 010901 (2015).
- *Efficient inference of parsimonious phenomenological models of cellular dynamics using S-systems and alternating regression.*
Bryan C. Daniels and Ilya Nemenman.
PLOS ONE **10**, e0119821 (2015).
- *Sparse code of conflict in an animal society.*
Bryan C. Daniels, David C. Krakauer, and Jessica C. Flack.
Proc. Natl. Acad. Sci. USA **109**, 14259 (2012).
- *Nucleation at the DNA supercoiling transition.*
Bryan C. Daniels and James P. Sethna.
Phys. Rev. E **83**, 041924 (2011).

- *Saturation Probabilities of Continuous-Time Sigmoidal Networks.*
Randall D. Beer and Bryan C. Daniels.
arXiv:1010.1714 (q-bio.NC) (2010).
- *Discontinuities at the DNA supercoiling transition.*
Bryan C. Daniels, Scott Forth, Maxim Y. Sheinin, Michelle D. Wang, and James P. Sethna.
Phys. Rev. E **80**, 040901 (R) (2009).
- *Statistical properties of multistep enzyme-mediated reactions.*
Wiet H. de Ronde, Bryan C. Daniels, Andrew Mugler, Nikolai A. Sinitsyn, and Ilya Nemenman.
IET Systems Biology **3**, 429 (2009).
- *Sloppiness, robustness, and evolvability in systems biology.*
Bryan C. Daniels, Yan-Jiun Chen, James P. Sethna, Ryan N. Gutenkunst, and Christopher R. Myers.
Current Opinion in Biotechnology **19**, 389 (2008).
- *Abrupt Buckling Transition Observed during the Plectoneme Formation of Individual DNA Molecules.*
Scott Forth, Christopher Deufel, Maxim Y. Sheinin, Bryan Daniels, James P. Sethna, and Michelle D. Wang.
Phys. Rev. Lett. **100**, 148301 (2008).
- *Absence of Kondo lattice coherence effects in $Ce_{0.6}La_{0.4}Pb_3$: A magnetic-field study.*
Richard Pietri, Costel R. Rotundu, Bohdan Andraka, Bryan C. Daniels, and Kevin Ingersent.
J. Appl. Phys. **97**, 10A510 (2005).
- *Synchronization of Coupled Rotators: Josephson Junction Ladders and the Locally-Coupled Kuramoto Model.*
B. C. Daniels, S. T. M. Dissanayake, and B. R. Trees.
Phys. Rev. E **67**, 026216 (2003).

Book chapters

- *Inferring the Logic of Collective Information Processors.*
Bryan C. Daniels.
In *Advances in Info-Metrics: Information and Information Processing Across Disciplines*, ed. Min Chen, J. Michael Dunn, Amos Golan, and Aman Ullah. Oxford University Press (2020).
- *Parameter Estimation, Sloppiness, and Model Identifiability.*
Bryan C. Daniels, Dirk Fey, and Maciej Dobrzyński.
In *Quantitative Biology: Theory, Computational Methods, and Models*, ed. B. Munsky, W. Hlavacek, and L. Tsimring. MIT Press (2018).

In review

- *Subcritical escape waves in schooling fish.*
Winnie Poel, Bryan C. Daniels, Matthew M. G. Sosna, Colin R. Twomey, Simon P. Leblanc, Iain D. Couzin, and Pawel Romanczuk.
arXiv:2108.05537.

- *Discovering sparse control strategies in C. elegans.*
Edward D. Lee, Xiaowen Chen, and Bryan C. Daniels.
arXiv:2108.00837.
- *Neet: Simulating and Analyzing Dynamical Network Models.*
Douglas G. Moore, Harrison B. Smith, Bryan C. Daniels, Hyunju Kim, Bradley Karas, Siyu Zhou, and Sara I. Walker.
- *Emergent regularities and scaling in armed conflict data.*
Edward D. Lee, Bryan C. Daniels, Christopher R. Myers, David C. Krakauer, and Jessica C. Flack.
arXiv:1903.07762v2.

In preparation

- *Distance from criticality in adaptive collective behavior.*
Bryan C. Daniels, David C. Krakauer, and Jessica C. Flack.

Professional Activities

Meeting organization

- Feb. 2020 **Workshop: The Dynamics of Collective Decisions** *Organizer*, Wissenschaftskolleg zu Berlin (Berlin Institute for Advanced Study)
- May 2018 **Working Group: Distributed Decision Making – Universal features of decision making via collective computation** *Co-organizer*, Santa Fe Institute
- Sep. 2017 **Working Group: Quantifying Collective Behavior in Living Systems II** *Co-organizer*, Santa Fe Institute
- May 2017 **Working Group: Quantifying Collective Behavior in Living Systems** *Co-organizer*, Santa Fe Institute
- July 2014 **Working Group: Collective Cognition – Quantifying Distributed Inference** *Co-organizer*, Santa Fe Institute, (video summary here: vimeo.com/111008805)

Editing

- 2021 **Theory in Biosciences** *Special issue on Quantifying Collectivity*
- 2017–2021 **PLOS ONE** *Editorial Board member*

Committee service

- Apr. 2014 Kohler graduate fellowship selection committee member, UW–Madison

Refereeing — Journals

- Proc. Natl. Acad. Sci. USA
- Physical Review Letters
- PNAS Nexus
- Proceedings B: Biological Sciences
- J. Physics A: Math. Theor.
- J. Physics: Condensed Matter
- Animal Behavior
- Frontiers in Physiology
- eLife
- Entropy
- Nature Communications
- PLOS Computational Biology
- J. Royal Society Interface
- Physical Review E
- Physical Biology
- Journal of Complexity
- IEEE Mol. Bio. & Multi-Scale Comm.
- Bioinformatics
- BioSystems
- J. System Science & System Eng.

- Integrative Biology
- Trends in Cognitive Science
- IEEE Computational Intelligence
- Theory in Biosciences

Refereeing — Grants

- National Science Foundation
- Human Frontier Science Program
- ANR (French National Research Agency)
- NSERC (Canada)
- Israel Science Foundation

Student Supervision

- Gaurang Singh (IIT Bombay Master's student), independent research project. Arizona State University.
- Robin Na (Seoul National University visiting undergraduate student), summer internship. Arizona State University.
- Undergraduate and graduate student workers, Digital Innovation Group and Data Mining and Informatics research teams. Arizona State University.
- Edward Lee (Princeton physics, graduate student at Cornell, now postdoc at Santa Fe Institute), summer internship and post-undergraduate research. SFI, UW–Madison.
- Jess Banks (Oberlin math, now graduate student at UC–Berkeley), summer internship. UW–Madison.

Invited Talks

- Jan. 2022 Joint Mathematics Meetings. Session on “Complex Adaptive Systems and Evolutionary Models in Biology and Psychology.”
- May 2020 Emory University. Theory and Modeling of Living Systems. Virtual workshop: “Can machine learning learn new physics, or do we need to put it in by hand?”
- Jan. 2020 University of Muenster. Muenster Graduate School of Evolution. Lecture series: “The Growth of the Evolutionary Thought.”
- Jan. 2020 Max Planck Research Group Leader Symposium, Berlin.
- June 2019 Santa Fe Institute. CollectiveCrypto workshop: Exploring the Role of Collective Effects in Cryptonetwork & Token Design.
- Mar. 2019 Santa Fe Institute. SFI Studio event on Complexity for Intelligence Science.
- June 2018 Santa Fe Institute. Workshop on Limits of Human Performance: The Role of Collective Effects in Individual and Team Performance.
- Feb. 2018 University of Arizona. Applied Mathematics Colloquium.
- Mar. 2017 APS March Meeting. Invited session: Robot scientists and machine learning for automated modeling and control of complex systems (DBIO/GSNP).
- Dec. 2016 Los Alamos National Laboratory. Center for Nonlinear Studies.
- July 2016 Vanderbilt University. Selected for contributed talk at q-bio conference.
- Oct. 2015 Santa Fe Institute. Working group on Information Theory, Ecosystems, and Schrödinger's Paradox.
- June 2015 Champalimaud Neuroscience Programme, Lisbon, Portugal. Polavieja lab.
- Nov. 2014 University of Michigan. Center for the Study of Complex Systems Seminar.
- Oct. 2014 American University. Recent Innovations in Info-Metrics.

- May 2014 Santa Fe Institute. Workshop on Statistical Mechanics.
- Apr. 2014 University of Wisconsin–Madison. Chaos and Complex Systems Seminar.
- Jan. 2014 Georgia Tech. Selected for contributed talk at Dynamics Days conference.
- Dec. 2013 University of Wisconsin–Madison. SILO (Systems, Information, Learning, and Optimization) lecture.
- Oct. 2013 University of Wisconsin–Madison. SoundWaves public lecture.

Teaching

- 2021–present **Complex Adaptive Systems 503: Collectives**, Arizona State University
Online course covering examples of real-world collectives and the theory to describe their behavior.
- 2016–2018, **Anthropology/Biology/Sustainability 570: Fundamentals of Complex Adaptive System Science**, Arizona State University
2020–present
Co-taught with Manfred Laubichler, Michael Barton, and Enrico Borriello
- 2013–2014 **Genetics 677: Evolutionary Systems Biology**, University of Wisconsin–Madison
Co-taught with evolutionary biologist Laurence Loewe
- 2014 **Biochemistry 609: Mathematical Methods for Systems Biology** *Guest lecturer*, University of Wisconsin–Madison
- 2013 **Humanities Hackathon short course**, University of Wisconsin–Madison
Course development, workshop organization, and lectures on computational analysis techniques for a professional humanities audience.
- 2007–2009 **Physics Teaching assistant**, Cornell University
- Physics 218: Waves and Thermodynamics
 - Physics 317: Applications of Quantum Mechanics
 - Physics 2206: Weapons of Mass Destruction
 - Physics 1101: General Physics Autotutorial

Community Outreach

- 2021 **ASU Homecoming Block Party**
“Ask an Expert” public outreach for College of Global Futures
- 2009–present **Adopt-a-Physicist volunteer**
Online interaction with high school physics students
- 2020 **Neuromatch Academy**
Faculty mentor for online school in computational neuroscience
- 2014–2015 **High school field trip outreach events, Wisconsin Institute for Discovery**
Led a group of postdocs and graduate and undergraduate students to develop activities that demonstrate computational reasoning, complex systems research, and interdisciplinary science for a high school audience
- 2010–2011 **Service Learning Mentor, The Masters Program**
One-on-one and group mentorship with high school students
- 2008–2010 **Expanding Your Horizons volunteer**
Physics demonstrations for middle school girls