

# Noah D. Goodman

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## Research Interests

Computational models of cognition, integrating logic and probability.  
Probabilistic programming languages.  
Concepts, categorization, and intuitive theories.  
Natural language semantics and pragmatics.  
Social cognition.  
Causal learning and reasoning.  
Cognitive development.

## Professional Positions

Assistant Professor of Cognitive Psychology, Stanford University, 2010-.  
(By courtesy, Assistant Professor of Linguistics and of Computer Science.)

Research Scientist, Massachusetts Institute of Technology, 2008-2010.

Post-Doctoral Associate, Massachusetts Institute of Technology, 2005-2008.

Lecturer, St. Edwards University, 2004-2005.

## Education

Ph.D., Mathematics, University of Texas at Austin, 2003.

B.S. Physics, *Cum Laude*, University of Arizona, 1997.

B.A. Mathematics, *Cum Laude*, University of Arizona, 1997.

## Grants and Honors

### *Grants*

J. S. McDonnell Foundation Scholar Award, October 2010 – October 2016, \$600,000. (PI)

ONR, July 2009 – June 2012, \$458,802. (Co-PI; Tenenbaum PI)

## Honors

- 2011 International Joint Conference on Artificial Intelligence best poster prize.
- 2011 Cognitive Science Society paper prize for computational modeling of language.
- 2007 Cognitive Science Society paper prize for computational modeling of higher-level cognition.
- 2007 Cognitive Science Society paper prize for computational modeling of perception and action.
- NSF VIGRE Fellowship, 2001-2002.
- University of Texas Continuing Graduate Study Fellowship, 2001-2002.
- Bruton Graduate Fellowship, 2000.
- National Merit Scholarship, 1994-1997.

## Publications

### Journal Articles

- M. C. Frank and N. D. Goodman (to appear). Quantifying pragmatic inference in language games. *Science*.
- P. Shafto, N. D. Goodman, M. Frank (accepted pending revision). Learning from others: The consequences of social context for human learning. *Perspectives on Psychological Science*.
- E. Seiver, A. Gopnik, and N. D. Goodman (to appear). Did she jump because she was the big sister or because the trampoline was safe? Causal inference and the development of social attribution. *Child Development*.
- S.T. Piantadosi, J. B. Tenenbaum, and N. D. Goodman (2012). Bootstrapping in a language of thought: a formal model of numerical concept learning. *Cognition*.
- G. Scontras, P. Graff, and N. D. Goodman (2012). Comparing pluralities. *Cognition*.
- N. Chater, N. D. Goodman, T. L. Griffiths, C. Kemp, M. Oaksford, and J. B. Tenenbaum (2011). The imaginary fundamentalists: the unshocking truth about Bayesian cognitive science. *Behavioral and Brain Sciences*. (Commentary on Jones and Love.)
- C. Cook, N. D. Goodman, and L. Schulz (2011). Where science starts: Spontaneous experiments in preschoolers' exploratory play. *Cognition*.
- P. Shafto, E. Bonawitz, H. Gweon, N. D. Goodman, E. Spelke, and L. Schulz (2011). The double-edged sword of pedagogy: Instruction limits spontaneous exploration and discovery. *Cognition*.
- J. B. Tenenbaum, C. Kemp, T. L. Griffiths, and N. D. Goodman (2011). How to grow a mind: structure, statistics, and abstraction. *Science*.
- N. D. Goodman, T. D. Ullman, and J. B. Tenenbaum (2011). Learning a theory of causality. *Psychological Review*.
- T. M. Desrochers, D. Z. Jin, N. D. Goodman, and A. M. Graybiel (2010). Optimal habits can develop spontaneously through sensitivity to local cost. *Proceedings of the National Academy of Sciences*.
- C. Kemp, N. D. Goodman, and J. B. Tenenbaum (2010). Learning to learn causal models. *Cognitive Science*.

- L. Henderson, N. D. Goodman, J. B. Tenenbaum, and J. Woodward (2010). The structure and dynamics of scientific theories: a hierarchical Bayesian perspective. *Philosophy of Science*. 77:2, 172–200.
- M. Frank, N. D. Goodman, and J. B. Tenenbaum (2009). Using speakers' referential intentions to model early cross-situational word learning. *Psychological Science*. 20, 579–585.
- N. D. Goodman, J. B. Tenenbaum, J. Feldman, and T. L. Griffiths (2008). A rational analysis of rule-based concept learning. *Cognitive Science*. 32:1, 108–154.
- L. E. Schulz, N. D. Goodman, J. B. Tenenbaum, and A. Jenkins (2008). Going beyond the evidence: Abstract causal laws and preschoolers' responses to anomalous data. *Cognition*. 109:2, 211–223.
- E. Giroux and N. D. Goodman (2006). On the stable equivalence of open books in three-manifolds. *Geometry & Topology*.
- N. D. Goodman (2005). Overtwisted open books from sobering arcs. *Algebraic and Geometric Topology*.

### Refereed Conference Proceedings

- N. D. Goodman and A. Stülmueller (to appear). Knowledge and implicature: Modeling language understanding as social cognition. *Proceedings of the Thirty-Fourth Annual Conference of the Cognitive Science Society*.
- L. Bergen, N. D. Goodman, and R. Levy (to appear). That's what she (could have) said: How alternative utterances affect language use. *Proceedings of the Thirty-Fourth Annual Conference of the Cognitive Science Society*.
- T. Gerstenberg, and N. D. Goodman (to appear). Ping Pong in Church: Productive use of concepts in human probabilistic inference. *Proceedings of the Thirty-Fourth Annual Conference of the Cognitive Science Society*.
- T. Gerstenberg, N. D. Goodman, D. A. Lagnado, and J. B. Tenenbaum (to appear). Noisy Newtons: Unifying process and dependency accounts of causal attribution. *Proceedings of the Thirty-Fourth Annual Conference of the Cognitive Science Society*.
- D. Lassiter, and N. D. Goodman (to appear). How many kinds of reasoning? Inference, probability, and natural language semantics. *Proceedings of the Thirty-Fourth Annual Conference of the Cognitive Science Society*.
- Y. Yeh, L. Yang, M. Watson, N. D. Goodman, P. Hanrahan (to appear). Synthesizing Open Worlds with Constraints using Locally Annealed Reversible Jump MCMC. *SIGGRAPH 2012*.
- D. Wingate, N. D. Goodman, A. Stülmueller, and J. Siskind (2011). Nonstandard Interpretations of Probabilistic Programs for Efficient Inference. *Advances in Neural Information Processing Systems*, 24.
- A. Stiller, N. D. Goodman, and M. C. Frank (2011). Ad-hoc scalar implicature in adults and children. *Proceedings of the Thirty-Third Annual Conference of the Cognitive Science Society*.
- T. J. O'Donnell, J. Snedeker, J. B. Tenenbaum, and N. D. Goodman (2011). Productivity and reuse in language. *Proceedings of the Thirty-Third Annual Conference of the Cognitive Science Society*. **[Winner of the 2011 Cognitive Science Society computational modeling prize for Language.]**
- D. Wingate, L. Kaelbling, D. Roy, N. D. Goodman and J. B. Tenenbaum (2011). Bayesian Policy Search with Policy Priors. *IJCAI 2011*. **[Winner of the Best Poster prize.]**
- D. Wingate, A. Stülmueller, N. D. Goodman (2011). Lightweight Implementations of Probabilistic Programming Languages Via Transformational Compilation. *Artificial Intelligence and Statistics 2011*.

- S. T. Piantadosi, J. B. Tenenbaum, and N. D. Goodman (2010). Beyond Boolean logic: exploring representation languages for learning complex concepts. *Proceedings of the Thirty-Second Annual Conference of the Cognitive Science Society*.
- A. Stülmueller, J. B. Tenenbaum, and N. D. Goodman (2010). Learning Structured Generative Concepts. *Proceedings of the Thirty-Second Annual Conference of the Cognitive Science Society*.
- P. Shafto, N. D. Goodman, B. Gerstle, and F. Ladusaw (2010). Prior expectations in pedagogical situations. *Proceedings of the Thirty-Second Annual Conference of the Cognitive Science Society*.
- T. D. Ullman, N. D. Goodman, and J. B. Tenenbaum (2010). Theory learning as stochastic search. *Proceedings of the Thirty-Second Annual Conference of the Cognitive Science Society*.
- T. Ullman, C. L. Baker, O. Macindoe, O. Evans, N. D. Goodman, and J. B. Tenenbaum (2010). Help or hinder: Bayesian models of social goal inference. *Advances in Neural Information Processing Systems*, 22.
- N. D. Goodman, T. Ullman, and J. B. Tenenbaum (2009). Learning a theory of causality. *Proceedings of the Thirty-First Annual Conference of the Cognitive Science Society*.
- N. D. Goodman, C. L. Baker, and J. B. Tenenbaum (2009). Cause and intent: Social reasoning in causal learning. *Proceedings of the Thirty-First Annual Conference of the Cognitive Science Society*.
- L. Schmidt, N. D. Goodman, D. Barner, and J. B. Tenenbaum (2009). How tall is tall? Compositionality, statistics, and gradable adjectives. *Proceedings of the Thirty-First Annual Conference of the Cognitive Science Society*.
- E. Vul, N. D. Goodman, T. L. Griffiths, J. B. Tenenbaum (2009). One and done: Globally optimal behavior from locally suboptimal decisions. *Proceedings of the Thirty-First Annual Conference of the Cognitive Science Society*.
- M. C. Frank, N. D. Goodman, P. Lai, and J. B. Tenenbaum (2009). Informative communication in word production and word learning. *Proceedings of the Thirty-First Annual Conference of the Cognitive Science Society*.
- M. C. Frank, N. D. Goodman, J. B. Tenenbaum, and A. Fernald (2009). Continuity of discourse provides information for word learning. *Proceedings of the Thirty-First Annual Conference of the Cognitive Science Society*.
- D. Wingate, N. D. Goodman, D. M. Roy, and J. B. Tenenbaum (2009). The infinite latent events model. *Uncertainty in Artificial Intelligence 2009*.
- N. D. Goodman, V. K. Mansighka, D. Roy, K. Bonawitz, J. B. Tenenbaum (2008). Church: a language for generative models. *Uncertainty in Artificial Intelligence 2008*.
- C. L. Baker, N. D. Goodman, and J. B. Tenenbaum (2008). Theory-based social goal induction. *Proceedings of the Thirtieth Annual Conference of the Cognitive Science Society*.
- Y. Katz, N. D. Goodman, K. Kersting, C. Kemp, and J. B. Tenenbaum (2008). Modeling semantic cognition as logical dimensionality reduction. *Proceedings of the Thirtieth Annual Conference of the Cognitive Science Society*.
- R. Mayrhofer, N. D. Goodman, M. Waldmann, and J. B. Tenenbaum (2008). Structured correlation from the causal background. *Proceedings of the Thirtieth Annual Conference of the Cognitive Science Society*.
- C. Kemp, N. D. Goodman, and J. B. Tenenbaum (2008). Theory acquisition and the language of thought. *Proceedings of the Thirtieth Annual Conference of the Cognitive Science Society*.

- S. T. Piantadosi, N. D. Goodman, B. A. Ellis, and J. B. Tenenbaum (2008). Bayesian model of compositional semantics acquisition. *Proceedings of the Thirtieth Annual Conference of the Cognitive Science Society*.
- P. Shafto, and N. D. Goodman (2008). Teaching games: statistical sampling assumptions for learning in pedagogical situations. *Proceedings of the Thirtieth Annual Conference of the Cognitive Science Society*.
- M. C. Frank, N. D. Goodman, and J. B. Tenenbaum (2008). A Bayesian framework for cross-situational word-learning. *Advances in Neural Information Processing Systems*, 20.
- C. Kemp, N. D. Goodman, and J. B. Tenenbaum (2008). Learning relational theories. *Advances in Neural Information Processing Systems*, 20.
- N. D. Goodman, V. K. Mansinghka, and J. B. Tenenbaum (2007). Learning grounded causal models. *Proceedings of the Twenty-Ninth Annual Conference of the Cognitive Science Society*. [**Winner of the 2007 Cognitive Science Society computational modeling prize for Perception and Action.**]
- C. Kemp, N. D. Goodman, and J. B. Tenenbaum (2007). Learning causal schemata. *Proceedings of the Twenty-Ninth Annual Conference of the Cognitive Science Society*. [**Winner of the 2007 Cognitive Science Society computational modeling prize for Higher-level Cognition.**]
- N. D. Goodman, T. L. Griffiths, J. Feldman, and J. B. Tenenbaum (2007). A rational analysis of rule-based concept learning. *Proceedings of the Twenty-Ninth Annual Conference of the Cognitive Science Society*.
- L. Henderson, N. D. Goodman, J. B. Tenenbaum, and J. Woodward (2007). Frameworks in science: a Bayesian approach. *LSE-Pitt Conference: Confirmation, Induction and Science*.
- N. D. Goodman, C. L. Baker, E. B. Bonawitz, V. K. Mansinghka, A. Gopnik, H. Wellman, L. Schulz, and J. B. Tenenbaum (2006). Intuitive theories of mind: A rational approach to false belief. *Proceedings of the Twenty-Eighth Annual Conference of the Cognitive Science Society*.

## Chapters

- N. D. Goodman, J. B. Tenenbaum, T. L. Griffiths, and J. Feldman (2008). Compositionality in rational analysis: Grammar-based induction for concept learning. In M. Oaksford and N. Chater (Eds.), *The probabilistic mind: Prospects for Bayesian cognitive science*.

## Books

- J. B. Tenenbaum, T. L. Griffiths, N. Chater, C. Kemp, N. D. Goodman, A. Yuille (to be completed in 2012). *Reverse engineering the mind: the Bayesian approach*.

## Technical Reports

- I. Hwang, A. Stuhlmüller, and N. D. Goodman. Inducing Probabilistic Programs by Bayesian Program Merging (2011). arXiv:1110.5667
- T. J. O'Donnell, N. D. Goodman, and J. B. Tenenbaum. Fragment Grammars: Exploring Computation and Reuse in Language (2009). Technical Report MIT-CSAIL-TR-2009-013, Massachusetts Institute of Technology.
- D. McAllester, B. Milch, and N. D. Goodman (2008). Random-world semantics and syntactic independence for expressive languages. Technical Report MIT-CSAIL-TR-2008-025, Massachusetts Institute of Technology.

## Software

MIT-Church, Bher, Cosh.

Implementations of the Church probabilistic programming language.

## Popular Press (selected articles)

“A grand unified theory of AI,” MIT News, March 30, 2010. (Picked up by slashdot.org, reddit.com, etc.)

“I, algorithm.” New Scientist, January 29, 2011.

“More Than Child’s Play: Ability to Think Scientifically Declines as Kids Grow Up.” Scientific American, September 21, 2011.

## Invited Presentations

International Congress on Computer Vision, Vision Grammars Workshop, Barcelona, Spain, November 2011.

UC Berkeley Institute for Human Development seminar, Berkeley, CA, October 2011.

UC Berkeley Institute for Cognitive and Brain Sciences seminar, Berkeley, CA, September 2011.

Gatsby Unit special seminar, University College, London, UK, September 2011.

London Judgment and Decision Making seminar, London, UK, September 2011.

AAAI workshop on Plan and Intent Recognition, San Francisco, CA, August 2011.

UC Merced Cognitive and Information Sciences Colloquium, Merced, CA, March 2011.

UCSC Psychology Colloquium, Santa Cruz, CA, February 2011.

Neural Information Processing Systems workshop “Modeling human communication dynamics”. Whistler, BC, December 2010.

SRI, Menlo Park, CA, November 2010.

UCSD Psychology Colloquium, San Diego, CA, November 2010.

CSLI Symposium, Stanford University, Stanford, CA, October 2010.

Humanity+ Summit, Harvard University, Cambridge, MA, June 2010.

Cornell Workshop on Grammar Induction, Ithaca, NY, May 2010.

Massachusetts General Hospital, Biostatistics Seminar. Boston, MA, March 2010.

Johns Hopkins University, Psychology Department special seminar. Baltimore, MD, January 2010.

Stanford University, Psychology Department special seminar. Stanford, CA, January 2010.

University of Rochester, Brain and Cognitive Sciences colloquium. Rochester, NY, October 2009.

University of Michigan, Developmental Psychology Brown Bag seminar. Ann Arbor, MI, October 2009.

- Brown University, Pattern Theory seminar. Providence, RI, October 2009.
- University of Edinburgh, Informatics Division colloquium. Edinburgh, UK, July 2009.
- Banff International Research Station workshop "Probabilistic models of cognitive development". Banff, BC, May 2009.
- Invited commentary, Interdisciplinary Graduate Conference on Consciousness. Boston, MA, April 2009.
- MIT, Brain and Cognitive Sciences special seminar. Boston, MA, March 2009.
- Neural Information Processing Systems workshop "Probabilistic programming", Whistler, BC, December 2008.
- Neural Information Processing Systems workshop "Human learning meets machine learning". Whistler, BC, December 2008.
- New York University, Developmental Psychology seminar. New York, NY, October 2008.
- Keynote speaker, International Conference on Inductive Logic Programming. Prague, September 2008.
- University of Texas, Cognitive Psychology seminar. Austin, TX, August 2008.
- Center for Advanced Study in the Behavioral Sciences workshop "Early mechanisms of understanding social causation" (Festschrift for John S. Watson). Stanford, CA, April 2008.
- International Conference on Infant Studies invited symposium "From statistical regularities to conceptual inference". Vancouver, BC, March 2008.
- ONR Workshop on Computational Social Cognition. MIT, Cambridge, MA, March 2008.
- Harvard university, Psychology colloquium. Cambridge, MA, February 2008.
- University of California, Berkeley, Computational Cognitive Science seminar. Berkeley, CA, November 2007.
- AAAI Fall Symposia workshop "Representation Change". Washington, DC, November 2007.
- Society for Philosophy and Psychology. Toronto, ON, June 2007. (Invited commentary on D. Lyons, "Covert Rationality: Overimitation and the Structure of Children's Causal Learning".)
- McDonnell Foundation Workshop on Moral Cognition. Pasadena, CA, May 2007.
- University of Salzburg, Institute fur Psychologie colloquium. Salzburg, AU, April 2007.
- University of Göttingen, Cognitive and Decision Sciences seminar. Göttingen, GM, April 2007.
- Rutgers University, Center for Cognitive Science seminar. Piscataway, NJ, March 2007.
- Society for Philosophy and Psychology, Invited symposium on Causality. St. Luis, MO, June 2006.
- University of California, Berkeley, Cognitive Development seminar. Berkeley, CA, 2006.
- University of Michigan, Developmental Psychology seminar. Ann Arbor, MI, 2006.
- Brown University, Cognitive Science seminar. Providence, RI, 2005.
- M.I.T., Computational Cognitive Science seminar. Cambridge, MA, December 2004.

Bryn Mawr College, Contact Topology seminar. Bryn Mawr, PA, April 2003.

University of Pennsylvania, Department of Mathematics Geometry-Topology seminar. Philadelphia, PA, January 2003.

University of Texas at Austin, Department of Mathematics Topology seminar. Austin, TX, March 2002.

Columbia University, Department of Mathematics Topology seminar. New York, NY, March 2001.

State University of New York, Department of Mathematics Geometry seminar. Stony Brook, NY, March 2001.

## Professional Services

Journal Reviewer: Science. Cognition. Child Development. Cognitive Science. Memory and Cognition. Cognitive Psychology. Journal of Mathematical Psychology. Cognitive Processing. Journal of Experimental Psychology: Learning, Memory, & Cognition. Journal of Experimental Psychology: General. Philosophical Transactions A.

Conference Proceedings Reviewer: Cognitive Science. Neural Information Processing Systems. Society for Philosophy and Psychology. Uncertainty in Artificial Intelligence. TARK.

Area chair: NIPS 2011. Granada, Spain, December 2011.

Co-Organizer: IPAM summer school "Probabilistic Models of Cognition". Los Angeles, CA, July 2011.

Organizer: workshop "Probabilistic Programming in AI". Los Altos, CA, January 2010.

Co-Organizer: NIPS workshop "Bounded-rational analyses of human cognition: Bayesian models, approximate inference, and the brain". Whistler, BC, December 2009.

Program committee: International Workshop on Statistical Relational Learning. Leuven, Belgium, July 2009.

Co-Organizer: Cognitive Science Society, workshop "Intuitive pedagogical reasoning: an interdisciplinary workshop". Amsterdam, Netherlands, August 2009.

Co-Organizer: Annual Summer Interdisciplinary Conference, symposium "Bayesian models in psychology". Valle d'Aosta, Italy, July 2009.

Co-Organizer: Eastern Psychology Association, workshop "Social routes to causal knowledge: action, imitation, and pedagogy". Boston, MA, March 2008.

Co-Organizer: McDonnell Foundation workshop "Explanation and prior knowledge". Cambridge, MA, November 2006.

Mentor (1999-2001), Visiting Lecturer (2006, 2008, 2010, 2011), Canada/USA Mathcamp.

Co-Organizer and Coordinator of Hiring, Canada/USA Mathcamp 2000, 2001.

## Teaching and Advising

### *Courses Taught*

“Computation and Cognition: the Probabilistic Approach” (Psych 204). Stanford. Winter 2012.

“Formal and Computational Approaches in Psychology and Cognitive Science” (Psych 239). Stanford. Spring 2011. (Co-taught with J. McClelland.)

“Computation and Cognition: the Probabilistic Approach” (Psych 204). Stanford. Winter 2011.

“Computational Cognitive Science: Probability, Programs, and the Mind.” European Summer School of Logic Language and Information. Copenhagen, August 2010.

Tutorial on probabilistic models of cognition (with T. O’Donnell). Cornell University, October 2009.

Co-taught (with L. Schulz and C. Moore): “Perception, Conception, and Action: Grounding Thoughts in Experience (and Vice Versa)”, M.I.T., Spring 2008.

IPAM Graduate Summer School: “Probabilistic Models of Cognition: The Mathematics of Mind”, Los Angeles CA, July 2007. (3 lectures.)

Extensive experience teaching mathematics at all levels, 1997-2005. (Details by request.)

### *Ph.D. students (principal advisor)*

Andreas Stuhmueller (MIT, BCS).

Long Ouyang (Stanford, Psychology).

Justine Kao (Stanford, Psychology).

### *Ph.D. Committees*

Tomer Ulman (MIT, BCS)

Yi-Ting Yeh (Stanford, Computer Science)

Jeremy Glick (Stanford, Psychology), completed 2011.

Daniel Sternberg (Stanford, Psychology), completed 2011.

Steve Piantadosi (MIT, BCS), completed 2011.

Timothy J. O’Donnell (Harvard, Psychology), completed 2011.

Jerry Talton (Stanford, Computer Science), completed 2011.

## University Committees

Psychology Department, Graduate Program Committee, 2011-2012.

Psychology Department, Graduate Admissions Committee, 2011-2012.

Psychology Department, Cognitive Search Committee, 2011-2012.

Psychology Department, Computer Committee, 2011-2012.

Psychology Department, Cognitive Search Committee, 2010-2011.

## Miscellaneous:

Citizen of the USA.

Member Cognitive Science Society.

Member Psychonomic Society.

Last updated: April 17, 2012