

# *Curriculum Vitae*

***Samuel J. Gershman***

## **PERSONAL DETAILS**

Samuel J. Gershman  
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## **EMPLOYMENT HISTORY**

Assistant Professor	2015-
Department of Psychology and Center for Brain Science, Harvard University	
Postdoctoral fellow	2013-2015
Department of Brain and Cognitive Sciences, MIT	

## **EDUCATION**

BA	Neuroscience and Behavior Columbia University	2003-2007
PhD	Psychology and Neuroscience Princeton University (advisors: Kenneth Norman & Yael Niv)	2008-2013

## **FUNDING**

2017-2020	ONR Science of Autonomy – Structured reinforcement learning in the brain (role: PI)
2017-2022	ONR MURI - A Computational Cognitive Neuroscience Approach to Understanding Event Representation and Episodic Memory (role: co-I)
2015-2018	NIH R01 - Representational foundations of adaptive behavior in natural and artificial agents (role: co-I with Nathaniel Daw (PI) and George Konidaris)
2017-2018	Harvard Foundations of Human Behavior Initiative - Computational and Neural Mechanisms of Information Seeking Behavior (role: PI)
2016-2017	Harvard Foundations of Human Behavior Initiative - Goals, habits and theory of mind: experimental and computational studies (role: co-PI with Fiery Cushman)
2016-2017	Harvard Brain Initiative Collaborative Seed Grant - Neurocomputational mechanisms of structure discovery (role: co-PI with Jan Drugowitsch)

- 2016- Google Research Grant - Research focusing on the use of video games environments to probe human planning, exploration, and inference (role: PI)
- 2015-2016 Harvard Mind/Brain/Behavior Initiative - Representation of hidden state in the dopamine system (role: co-PI with Naoshige Uchida)

### **FELLOWSHIPS and AWARDS**

- 2015 Clever Systems Early Career Investigator Award from the APA
- 2014 Glushko Dissertation Award from the Cognitive Science Society
- 2013 MIT Intelligence Initiative Postdoctoral Fellowship
- 2012 International Conference for Machine Learning travel award
- 2010 NSF graduate research fellowship
- 2009 NIPS travel award
- 2009 NIMH Quantitative and Computational Neuroscience training fellowship
- 2009 Swartz COSYNE travel fellowship
- 2008 Walker McKinney '50 Life Sciences Fellowship
- 2006 Summer University Research Fellowship, Columbia University

### **INVITED TALKS**

- Cognitive lunch seminar, Indiana University (April, 2010)
- Pavlovian Society annual meeting, Baltimore (October, 2010)
- Cognitive science seminar, University of Texas (February 2011)
- Organization for Human Brain Mapping meeting (June 2012)
- Oxford University, Department of Experimental Psychology (July 2012)
- Gatsby Computational Neuroscience Unit (July 2012)
- Pavlovian Society annual meeting, Jersey City (September, 2012)
- Society for computational modeling of associative learning, Jersey City (September, 2012)
- Brown University, Department of Cognitive, Linguistic and Psychological Sciences colloquium (December, 2012)
- Harvard University, Center for Brain Sciences (February 2014)
- University of California, Berkeley, Department of Psychology (February 2014)
- Columbia University, Department of Psychology (February 2014)
- University of Zurich, Neuroeconomics seminar (September 2014)
- Tufts University, Cognitive science seminar (October 2014)
- Boston University, Brain, Behavior and Cognition seminar (March 2015)
- Caltech, Neuroeconomics seminar (April 2015)
- Harvard Center for Brain/Mind seminar series (June 2015)
- Yale University, Current Works in Behavior, Genetics, and Neuroscience (February 2016)
- University of Massachusetts, Amherst, Cognitive science seminar (September 2016)
- Google DeepMind (October 2016)

- Boston Veteran's Affairs hospital, Neuroimaging/neuropsychology lecture series (October 2016)
- University of Pennsylvania, Computational Neuroscience seminar (November 2016)
- Champalimaud Center for the Unknown, Quantitative Neuroscience Seminar (January 2017)
- New York University, Neuroeconomics colloquium (April 2017)
- Reinforcement learning and decision making conference, keynote speaker (June 2017)

## MANUSCRIPTS UNDER REVIEW

1. Saeedi, A., Kulkarni, T., Mansinghka, V.K., & Gershman, S.J. (submitted). Variational particle approximations.
2. Gershman, S.J., Goldwater, M.B., & Otto, A.R. (submitted). How confidence shapes choice.
3. Russek, E., Momennejad, I., Botvinick, M.M., Gershman, S.J., & Daw, N.D. (submitted). Predictive representations can link model-based reinforcement learning to model-free mechanisms.
4. Starkweather, C.K., Gershman, S.J., & Uchida, N. (submitted). Medial prefrontal cortex shapes dopamine reward prediction errors under state uncertainty.
5. Stachenfeld, K.L., Botvinick, M.M., & Gershman, S.J. (submitted). The hippocampus as a predictive map.

## PUBLICATIONS

1. Gershman, S.J. (in press). Dopamine, inference and uncertainty. *Neural Computation*.
2. Kool, W., Gershman, S.J., & Cushman, F.A. (in press). Cost-benefit arbitration between multiple reinforcement learning systems. *Psychological Science*.
3. Gershman, S.J., Zhou, J., & Kommer, C. (in press). Imaginative reinforcement learning: computational principles and neural mechanisms. *Journal of Cognitive Neuroscience*.
4. Linderman, S.W., & Gershman, S.J. (in press). Using computational theory to constrain statistical models of neural data. *Current Opinion in Neurobiology*.
5. Momennejad, I., Russek, E., Cheong, J.H., Botvinick, M.M., Daw, N.D., & Gershman, S.J. (in press). The successor representation in human reinforcement learning. *Nature Human Behaviour*.
6. Lake, B.M., Ullman, T.D., Tenenbaum, J.B., & Gershman, S.J. (in press). Building machines that learn and think like people. *Behavioral and Brain Sciences*.
7. Kool, W., & Cushman, F.A., & Gershman, S.J. (in press). Competition and cooperation between multiple reinforcement learning systems. In R.W. Morris & A. Bornstein (Eds.) *Goal-Directed Decision Making: Computations and Neural Circuits*. Elsevier.

8. Gershman, S.J. & Beck, J.M. (in press). Complex probabilistic inference: from cognition to neural computation. In A. Moustafa (Ed.) *Computational Models of Brain and Behavior*. Wiley-Blackwell.
9. Dasgupta, I., Schulz, E., & Gershman, S.J. (2017). Where do hypotheses come from? *Cognitive Psychology*, *96*, 1-25.
10. Dasgupta, I., Schulz, E., Goodman, N.D., & Gershman, S.J. (2017). Amortized hypothesis generation. *Proceedings of the 39th Annual Conference of the Cognitive Science Society*.
11. Starkweather, C.K., Babayan, B.M., Uchida, N., & Gershman, S.J. (2017). Dopamine reward prediction errors reflect hidden state inference across time. *Nature Neuroscience*, *20*, 581-589.
12. Gershman, S.J. (2017). Predicting the past, remembering the future. *Current Opinion in Behavioral Sciences*, *17*, 7-13.
13. Thaker, P., Tenenbaum, J.B., & Gershman, S.J. (2017). Online learning of symbolic concepts. *Journal of Mathematical Psychology*, *77*, 10-20.
14. Gershman, S.J., Pouncy, H.T., & Gweon, H. (2017). Learning the structure of social influence. *Cognitive Science*, *41*, 545-575.
15. Gershman, S.J. (2017). Context-dependent learning and causal structure. *Psychonomic Bulletin & Review*, *24*, 557-565.
16. Gershman, S.J., Malmaud, J., & Tenenbaum, J.B. (2017). Structured representations of utility in combinatorial domains. *Decision*, *4*, 67-86.
17. Gershman, S.J. (2017). Reinforcement learning and causal models. In M. Waldmann, Ed, *Oxford Handbook of Causal Reasoning*. Oxford University Press.
18. Gershman, S.J. & Daw, N.D. (2017). Reinforcement learning and episodic memory in humans and animals: an integrative framework. *Annual Review of Psychology*, *68*, 101-128.
19. Gershman, S.J., Monfils, M.-H., Norman, K.A., & Niv, Y. (2017). The computational nature of memory modification. *eLife*.
20. Gershman, S.J. (2017). On the blessing of abstraction. *The Quarterly Journal of Experimental Psychology*, *70*, 361-365.
21. Gershman, S.J., Tenenbaum, J.B., & Jäkel, F.J. (2016). Discovering hierarchical motion structure. *Vision Research*, *126*, 232-241.
22. Pereira, F., Gershman, S.J., Ritter, S., & Botvinick, M.M. (2016). A comparative evaluation of off-the-shelf distributed semantic representations for modelling behavioural data. *Cognitive Neuropsychology*, *33*, 175-190.
23. Schulz, E., Tenenbaum, J.B., Duvenaud, D., Speekenbrink, M., & Gershman, S.J. (2016). Probing the compositionality of intuitive functions. *Advances in Neural Information Processing Systems*, *29*.
24. Gershman, S.J., Gerstenberg, T., Baker, C.L., & Cushman, F.A. (2016). Plans, habits, and theory of mind. *PLOS One*, *11*, e0162246.
25. Kool, W., Cushman, F.A., & Gershman, S.J. (2016). When does model-based control pay off? *PLOS Computational Biology*, *12*, e1005090.
26. Ullman, T.D., Siegel, M., Tenenbaum, J.B., & Gershman, S.J. (2016). Coalescing the vapors of human experience into a viable and meaningful comprehension. *Proceedings of the 38th Annual Conference of the Cognitive Science Society*.

27. Batmanghelich, K., Saeedi, A., Narasimhan, K., & Gershman, S.J. (2016). Nonparametric spherical topic modeling with word embeddings. *Proceedings of the 54th Annual Meeting of the Association for Computational Linguistics*.
28. Gershman, S.J. (2016). Empirical priors for reinforcement learning models. *Journal of Mathematical Psychology*, 71, 1-6.
29. Tervo, D.G.R., Tenenbaum, J.B., & Gershman, S.J. (2016). Towards the neural implementation of structure learning. *Current Opinion in Neurobiology*, 37, 99-105.
30. Gershman, S.J. (2015). A unifying probabilistic view of associative learning. *PLOS Computational Biology*, 11, e1004567.
31. Gershman, S.J. (2015). Do learning rates adapt to the distribution of rewards? *Psychonomic Bulletin & Review*, 22, 1320-1327.
32. Gershman, S.J., Norman, K.A., & Niv, Y. (2015). Discovering latent causes in reinforcement learning. *Current Opinion in Behavioral Sciences*, 5, 43-50.
33. Gershman, S.J. & Tenenbaum, J.B. (2015). Phrase similarity in humans and machines. *Proceedings of the 37th Annual Conference of the Cognitive Science Society*.
34. Schulz, E., Tenenbaum, J.B., Reshef, D.N., Speekenbrink, M., & Gershman, S.J. (2015). Assessing the perceived predictability of functions. *Proceedings of the 37th Annual Conference of the Cognitive Science Society*.
35. Gershman, S.J., Horvitz, E.J., & Tenenbaum, J.B. (2015). Computational rationality: a converging paradigm for intelligence in brains, minds and machines. *Science*, 349, 273-278.
36. Gershman, S.J. & Hartley, C.A. (2015). Individual differences in learning predict the return of fear. *Learning & Behavior*, 43, 243-250.
37. Niv, Y., Daniel, R., Geana, A., Gershman, S.J., Leong, Y.C., Radulescu, A., & Wilson, R.C. (2015). Reinforcement learning in multidimensional environments relies on attention mechanisms. *Journal of Neuroscience*, 35, 8145-8157.
38. Huys, Q.J.M., Lally, N., Faulkner, P., Eshel, N., Seifritz, E., Gershman, S.J., Dayan, P., & Roiser, J.P. (2015). The interplay of approximate planning strategies. *Proceedings of the National Academy of Sciences*, 112, 3098-3103.
39. Gershman, S.J. & Niv, Y. (2015). Novelty and inductive generalization in human reinforcement learning. *Topics in Cognitive Science*, 1-25.
40. Gershman, S.J., Frazier, P.I., & Blei, D.M. (2015). Distance dependent infinite latent feature models. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 37, 334-345.
41. Austerweil, J.L., Gershman, S.J., Tenenbaum, J.B., & Griffiths, T.L. (2015). Structure and flexibility in Bayesian models of cognition. In J.R. Busemeyer, J.T. Townsend, Z. Wang, & A. Eidels, Eds, *Oxford Handbook of Computational and Mathematical Psychology*. Oxford University Press.
42. Stachenfeld, K.L., Botvinick, M.M., & Gershman, S.J. (2014). Design principles of the hippocampal cognitive map. *Advances in Neural Information Processing Systems* 27.

43. Gershman, S.J., Radulescu, A., Norman, K.A., & Niv, Y. (2014). Statistical computations underlying the dynamics of memory updating. *PLOS Computational Biology*, *10*, e1003939.
44. Gershman, S.J., Blei, D.M., Norman, K.A., & Sederberg, P.B. (2014). Decomposing spatiotemporal brain images into topographic latent sources. *NeuroImage*, *98*, 91-102.
45. Gershman, S.J. (2014). The penumbra of learning: A statistical theory of synaptic tagging and capture. *Network: Computation in Neural Systems*, *25*, 97-115.
46. Soto, F.A., Gershman, S.J., & Niv, Y. (2014). Explaining compound generalization in associative and causal learning through rational principles of dimensional generalization. *Psychological Review*, *121*, 526-558.
47. Gershman, S.J. & Goodman, N.D. (2014). Amortized inference in probabilistic reasoning. *Proceedings of the 36<sup>th</sup> Annual Conference of the Cognitive Science Society*.
48. Tsividis, P., Gershman, S.J., Tenenbaum, J.B., & Schulz, L. (2014). Information selection in noisy environments with large action spaces. *Proceedings of the 36<sup>th</sup> Annual Conference of the Cognitive Science Society*.
49. Feng, S.F., Schwemmer, M., Gershman, S.J., & Cohen, J.D. (2014). Multitasking vs. multiplexing: Toward a normative account of capacity constraints in cognitive control. *Cognitive, Affective, and Behavioral Neuroscience*, *14*, 129-146.
50. Gershman, S.J., Moustafa, A.A., & Ludvig, E.A. (2014). Time representation in reinforcement learning models of the basal ganglia. *Frontiers in Computational Neuroscience*.
51. Gershman, S.J., Markman, A.B., & Otto, A.R. (2014). Retrospective reevaluation in sequential decision making: a tale of two systems. *Journal of Experimental Psychology: General*, *143*, 182-194.
52. Gershman, S.J. (2014). Dopamine ramps are a consequence of reward prediction errors. *Neural Computation*, *26*, 467-471.
53. Gershman, S.J. (2013). Computation with dopaminergic modulation. In Jaeger, D., Jung, R. (Ed.) *Encyclopedia of Computational Neuroscience*. Springer.
54. Gershman, S.J. (2013). Bayesian behavioral data analysis. In Jaeger, D., Jung, R. (Ed.) *Encyclopedia of Computational Neuroscience*. Springer.
55. Gershman, S.J., Jones, C.E., Norman, K.A., Monfils, M.-H., & Niv, Y. (2013). Gradual extinction prevents the return of fear. *Frontiers in Behavioral Neuroscience*. doi: 10.3389/fnbeh.2013.00164.
56. Detre, G.J., Natarajan, A., Gershman, S.J., & Norman, K.A. (2013). Moderate levels of activation lead to forgetting in the think/no-think paradigm. *Neuropsychologia*, *51*, 2371-2388.
57. Gershman, S.J., & Niv, Y. (2013). Perceptual estimation obeys Occam's razor. *Frontiers in Psychology*, *23*, doi:10.3389/fpsyg.2013.00623.
58. Christakou, A., Gershman, S.J., Niv, Y., Simmons, A., Brammer, M., & Rubia, K. (2013). Neural and psychological maturation of decision-making in adolescence and young adulthood. *Journal of Cognitive Neuroscience*, *25*, 1807-1823.
59. Gershman, S.J., Schapiro, A.C., Hupbach, A., & Norman, K.A. (2013). Neural context reinstatement predicts memory misattribution. *Journal of Neuroscience*, *33*, 8590-8595.

60. Otto, A.R., Gershman, S.J., Markman, A.B., & Daw, N.D. (2013). The curse of planning: Dissecting multiple reinforcement learning systems by taxing the central executive. *Psychological Science*, *24*, 751-761.
61. Wingate, D., Diuk, C., O'Donnell, T.J., Tenenbaum, J.B., Gershman, S.J. (2013). Compositional policy priors. *CSAIL Technical Report 2013-007*.
62. Gershman, S.J., Jäkel, F.J., & Tenenbaum, J.B. (2013). Bayesian vector analysis and the perception of hierarchical motion. *Proceedings of the 35th Annual Conference of the Cognitive Science Society*.
63. Gershman, S.J. & Niv, Y (2012). Exploring a latent cause model of classical conditioning. *Learning & Behavior*, *40*, 255-268.
64. Gershman, S.J., Hoffman, M.D., & Blei, D.M. (2012). Nonparametric variational inference. *Proceedings of the 29th International Conference on Machine Learning*.
65. Gershman, S.J., Moore, C.D., Todd, M.T., Norman, K.A., & Sederberg, P.B. (2012). The successor representation and temporal context. *Neural Computation*, *5*, 1553-1568.
66. Gershman, S.J. & Blei, D.M. (2012). A tutorial on Bayesian nonparametric models. *Journal of Mathematical Psychology*, *56*, 1-12.
67. Gershman, S.J. & Daw, N.D. (2012). Perception, action and utility: the tangled skein. In M. Rabinovich, K. Friston, P. Varona (Ed.) *Principles of Brain Dynamics: Global State Interactions*. MIT Press.
68. Gershman, S.J., Vul, E., & Tenenbaum, J.B. (2012). Multistability and perceptual inference. *Neural Computation*, *24*, 1-24.
69. Gershman, S.J., Blei, D.M., Pereira, F., & Norman, K.A. (2011). A topographic latent source model for fMRI data. *NeuroImage*, *57*, 89-100.
70. Sederberg, P.B., Gershman, S.J., Polyn, S.M., & Norman, K.A. (2011). Human memory reconsolidation can be explained using the Temporal Context Model. *Psychonomic Bulletin and Review*, *18*, 455-468.
71. Daw, N.D., Gershman, S.J., Seymour, B., Dayan, P., & Dolan, R.J. (2011). Model-based influences on humans' choices and striatal prediction errors. *Neuron*, *69*, 1204-1215.
72. Gershman, S.J. & Wilson, R.C. (2010). The neural costs of optimal control, *Advances in Neural Information Processing Systems* *23*.
73. Gershman, S.J, Cohen, J.D., & Niv, Y. (2010). Learning to selectively attend, *Proceedings of the 32nd Annual Conference of the Cognitive Science Society*.
74. Gershman, S.J & Niv, Y. (2010). Learning latent structure: Carving nature at its joints, *Current Opinion in Neurobiology*, *20*, 1-6.
75. Gershman, S.J., Blei, D.M., & Niv, Y. (2010). Context, learning, and extinction, *Psychological Review*, *117*, 197-209.
76. Gershman, S.J., Pesaran, B., & Daw, N.D. (2009). Human reinforcement learning subdivides structured action spaces by learning effector-specific values, *Journal of Neuroscience*, *29*, 13524-13531.
77. Gershman, S.J., Vul, E., & Tenenbaum, J.B. (2009). Perceptual multistability as Markov chain Monte Carlo inference, *Advances in Neural Information Processing Systems* *22*.

78. Socher, R., Gershman, S.J., Perotte, A., Sederberg, P.B., Blei, D.M., & Norman, K.A. (2009). A Bayesian analysis of dynamics in free recall, *Advances in Neural Information Processing Systems* 22.

**AD HOC REVIEWER** (alphabetical order)

Biological Cybernetics, Biological Psychiatry, Brain & Cognition, Cognition, Cognitive Science, CABN, Current Biology, Decision, Frontiers in Decision Neuroscience, Journal of Experimental Psychology: Learning, Memory & Cognition, Journal of Experimental Psychology: General, Journal of Machine Learning Research, Journal of Mathematical Psychology, Journal of Neuroscience, Journal of Neuroscience Methods, Learning & Memory, Neural Computation, Nature Communications, Nature Neuroscience, Neurobiology of Aging, NeuroImage, Neuron, Neuropsychologia, PLOS Computational Biology, PNAS, Psychological Review, Psychonomic Bulletin & Review, Science

**ASSOCIATE EDITOR**

PLOS Computational Biology

**AD HOC EDITOR**

eLife

**REVIEWING EDITOR**

Psychological Review

**TEACHING**

**Cognition: Mind and Brain** (Spring 2007), Columbia University—teaching assistant

**Animal learning and decision making: psychological, computational and neural perspectives** (Fall 2010), Princeton University—teaching assistant

**Computational Cognitive Neuroscience** (Fall 2016, yearly thereafter), Harvard University

**Debugging the Brain** (Spring 2018, yearly thereafter), Harvard University