Timothy J. Buschman

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Education

2008   **Massachusetts Institute of Technology**
    Ph.D. in Neuroscience under the supervision of Dr. Earl K. Miller
2001   **California Institute of Technology**
    B.S. in Biology

Current Positions

2013-   **Princeton University**
    Assistant Professor, Princeton Neuroscience Institute and Department of Psychology

Past Positions

2010-2013   **Massachusetts Institute of Technology**
    Postdoctoral Fellow with Dr. Christopher I. Moore
2011-2013   **Massachusetts Institute of Technology**
    Postdoctoral Fellow with Dr. Ed Boyden
2008-2010   **Massachusetts Institute of Technology**
    Postdoctoral Associate with Dr. Earl K. Miller
2002-2008   **Massachusetts Institute of Technology**
    Graduate Student with Dr. Earl K. Miller
2001-2002   **National Institute of Mental Health,** Laboratory of Neurophysiology
    Postbaccalaureate Intramural Research Training Award (IRTA) under the supervision of Drs.
    Robert Desimone, Pascal Fries and Elizabeth Buffalo.
2000-2001   **California Institute of Technology**
    Undergraduate research under the supervision of Dr. Christof Koch.
1994-1999   **Walter Reed Army Institute of Research**
    Research assistant under the supervision of Dr. Victor W. Macdonald.

Committees, Advisory Boards, and Other Professional Positions

2014-   Chair of Scientific Advisory Board, SplitSage. Commercial development of technologies taking
    advantage of discovery of independent cognitive capacities in the brain.
2010-2013   Consultant, BBN Technologies. Consulted on neurally-plausible, brain-based computational
    architectures for 'sense-making' of satellite imagery.

Professional Societies

2002-   **Society for Neuroscience**
2008-   **Faculty of 1000**

Editorial Activities

Ad hoc Reviewer for:
    Science
    eLife
    PNAS
    Neuron
    Nature Neuroscience

Current Biology
Cerebral Cortex
Nature Communications
Scientific Reports
Journal of Neuroscience
Journal of Experimental Psychology: General
Journal of Cognitive Neuroscience
Journal of Neurophysiology
Trends in Cognitive Sciences
Trends in Neurosciences
Frontiers in Human Neuroscience
Frontiers in Neural Circuits
Biological Reviews
Biological Cybernetics
Experimental Neurology
Computational and Systems Neuroscience (COSYNE) Meeting (2012, 2013, 2014, 2015, 2016)
Cognitive Computational Neuroscience (CCN) Meeting (2017, 2018)

Awards, Honors and Prizes

2014   **Awarded NIH Director's "New Innovator" Award**

2010   **Awarded K99/R00, Pathway to Independence Award by National Institute of Mental Health**
         NIMH/1 K99 MH092715-01 – Pathway to Independence Award

2009   **Buschman and Miller, *Science*, 2007 designated a Hot Paper by Thompson ISI**
         Designation was highlighted in <u>The Scientist</u> - http://www.the-scientist.com/2009/10/1/57/1/

2004   **Team Award for Outstanding Teaching**
         For teaching in Undergraduate Brain Lab in the department of Brain and Cognitive Science, MIT

1997   **FEEA/Blue Cross Blue Shield Special Distinction Scholarship**
         Assistance with undergraduate tuition; awarded for research at Walter Reed Army Institute of Research.

Patents

2016   Earl Keith Miller, **Timothy Joseph Buschman**, and Simon John Kornblith. *Dynamic Display System And Method For Customizing A Controller In A Display System.* Provisional Application; filed August 17, 2016. Describes a method for using neurophysiological signals to determine an individuals cognitive capacity. This can be used to improve performance on a variety of different tasks.

2014   **Timothy Joseph Buschman**, 2014. *Adaptive Cognitive Prosthetic and Applications Thereof.* Provisional Application; filed October 7, 2014. Describes a method for constructing a cognitive prosthetic for alleviating various neurological and/or neuropsychiatric disorders. In particular, we describe an adaptive cognitive prosthetics capable of learning to replace or augment function lost by a damaged or diseased brain region.

2011   Earl Keith Miller and **Timothy Joseph Buschman**. 2011. *Method And Apparatus Accounting for Independent Cognitive Capacities in the Right vs. Left Half of Vision.* U.S. Patent 9927940; filed June 3, 2011, issued March 27, 2018. Method for increasing information processing in visual displays. Based on neurophysiological and psychophysical understanding of our limited capacity to process information in visual displays. Method allows for display systems to dynamically adjust how, when, and where information is presented in order to maximize perceptual processing.

Peer-Reviewed Publications

1.   **Top-down versus bottom-up control of attention in the prefrontal and posterior parietal cortices**
         Buschman TJ and Miller EK.

Science 2007; 315 (5820): 1860-1862.

2. **Serial, covert shifts of attention during visual search are reflected by the frontal eye fields and correlated with population oscillations**
   Buschman TJ and Miller EK.
   Neuron 2009; 63 (3): 386-96.

3. **Shifting the spotlight of attention: evidence for discrete computations in cognition**
   Buschman TJ and Miller EK.
   Frontiers in Human Neuroscience 2010; 4: 194. doi: 10.3389/fnhum.2010.00194

4. **Comparison of primate prefrontal and premotor cortex neuronal activity during visual categorization**
   Cromer JA, Roy JE, **Buschman TJ** and Miller EK
   Journal of Cognitive Neuroscience, 2011. 23 (11): 3355-3365. doi:10.1162/jocn_a_00032

5. **Neural substrates of cognitive capacity limitations**
   Buschman TJ, Siegel M, Roy JE and Miller EK.
   Proceedings of the National Academy of Sciences USA 2011; 108(27) 11252-11255, doi: 10.1073/pnas.1104666108

6. **Laminar differences in gamma and alpha coherence in the ventral stream**
   Buffalo E, Fries P, Landman R, **Buschman TJ** and Desimone R
   Proceedings of the National Academy of Sciences USA 2011; 108(27) 11262-11267, doi: 10.1073/pnas.1011284108

7. **Synchronous oscillatory neural ensembles for rules in the prefrontal cortex**
   Buschman TJ, Denovellis E, Diogo C, Bullock D, Miller EK
   Neuron, 76: 838-846. 2012.

8. **Cortical circuits for the control of attention**
   Miller EK and **Buschman TJ**
   Current Opinion in Neurobiology, 2013.

9. **PFC Neurons Reflect Categorical Decisions about Ambiguous Stimuli**
   Roy JE, **Buschman TJ**, and Miller EK
   Journal of Cognitive Neuroscience, 26(6): 1283-91. 2014.

10. **Working memory capacity: Limits on the bandwidth of cognition**
    Miller EK and **Buschman TJ**
    Daedalus, 2014.

11. **Goal-direction and top-down control**
    Buschman TJ and Miller EK
    Philosophical Transactions of the Royal Society B, 2014. Nov 5;369(1655).

12. **Cortical Information Flow during Flexible Sensorimotor Decisions**
    Siegel M, **Buschman TJ** and Miller EK
    Science, 2015. Jun 19(348): 6241-2.

13. **From behavior to neural dynamics: An integrated theory of attention**
    Buschman TJ and Kastner S
    Neuron, 2015. Oct 88: 127-144.

14. **Gamma and Beta Bursts Underlie Working Memory.**
    Lundqvist M, Rose J, Herman P, Brincat SL, **Buschman TJ**, Miller EK
    Neuron, 2016. Apr 6; 90(1): 152-64.

15. **Stimulus Load and Oscillatory Activity in Higher Cortex**

Kornblith S, **Buschman TJ**, Miller EK
Cerebral Cortex, 2016. Aug 18.

16. **Working Memory Load Modulates Neuronal Coupling**
Pinotsis DA, **Buschman TJ**, Miller EK
Cerebral Cortex, 2018. Mar 28.

17. **Evidence supporting a role for astrocytes in the regulation of cognitive flexibility and neuronal**
Brockett AT, Kane GA, Monari PK, Briones BA, Vigneron PA, Barber GA, Bermudez A, Dieffenbach U, Kloth AD, **Buschman TJ**, Gould E
PLoS One, 2018, Apr 18.

18. **Intrinsic neuronal dynamics predict distinct functional roles during working memory**
Wasmuht DF, Spaak E, **Buschman TJ**, Miller EK, Stokes MG
Accepted at *Nature Communications;* available on *bioRxiv,* 2018.

19. **Error-correcting dynamics in visual working memory**
Panichello MF, DePasquale B, Pillow JW, **Buschman TJ**
In Revision at Nature Communications; available on *bioRxiv,* 2018. https://doi.org/10.1101/319103

20. **A flexible model of working memory**
Bouchacourt F and **Buschman TJ**
In Revision at Neuron; available on *bioRxiv,* 2018. https://doi.org/10.1101/407700

Non-peer reviewed scientific or medical publications/materials in print or other media

Bootstrapping Your Brain: How Interactions Between the Frontal Cortex and Basal Ganglia May Produce Organized Actions and Lofty Thoughts
Miller EK and **Buschman TJ**
Raymond P. Kesner and Joe L. Martinez (Eds.), *Neurobiology of learning and memory* (2nd edition, pp. 339 - 354). 2007. Oxford, UK: Elsevier.

Rules through Recursion: How Interactions between the Frontal Cortex and Basal Ganglia May Build Abstract, Complex Rules from Concrete, Simple Ones
Miller EK and **Buschman TJ**
Silvia A. Bunge and Jonathan D. Wallis (Eds.), *Neuroscience of rule-guided behavior* (1st edition, pp. 419 - 440). 2007. New York, NY: Oxford University Press.

Top-Down Control of Attention by Rhythmic Neural Computations
Miller EK and **Buschman TJ**
Posner, M.I. (ed) *Cognitive Neuroscience of Attention*, New York: Guilford Press, 2011

Brain Rhythms for Cognition and Consciousness
Miller EK and **Buschman TJ**
A. Battro, S. Dehaene and W. Singer (eds); *Neurosciences and the Human Person: New Perspectives on Human Activities*, Pontifical Academy of Sciences, Scripta Varia 121, Vatican City, 2013

Neural mechanisms for the executive control of attention
Miller EK and **Buschman TJ**
Kastner S and Nobre K(ed); *Oxford's Handbook of Attention*, Oxford University Press, January 2014

Paying Attention to the Details of Attention
Buschman TJ
Neuron 2015. Jun 3; 86(5): 1111-1113.

Dynamic coding for flexible cognitive control
Stokes M, **Buschman TJ**, and Miller EK
The Wiley Handbook of Cognitive Control, Ed. by Tobias Egner, John Wiley & Sons, (Chichester, West Sussex, UK).

Public Lectures and Scientific Outreach
2014   **BRAINWAVE at Rubin Musem of Art**, New York City

Invited Lectures and Presentations
2019   **Control Processes Meeting**, Providence RI, May 2019

2018   **University of Wisconsin**, Madison, WI, November 2018

         Columbia University, New York, NY, October 2018

         Washington University in St. Louis, St. Louis, MO, September 2018

         FENS, Berlin Germany, July 2018

         New York University, New York, NY, March 2018

2017   **Florida Atlantic University**, Orlando FL, March 2017

2016   **Neurobiology of Cognition Gordon Research Conference**, Newry ME, July 2016

         Neuroscience 2016, Annual Meeting of the Japan Neuroscience Society, Pacifico Yokohama, July 2016

         Osaka University and CiNET, Osaka Japan, July 2016

         University of Saskatchewan, Saskatoon, Canada, March 2016

         Cosyne Conference – Oscillations Workshop, Speaker, Salt Lake City, UT, March 2016

         Cosyne Conference – Executive Flexibility Workshop, Organizer and Speaker, Salt Lake City, UT, March 2016

         Yale University, New Haven, CT, January 2016

2015   **University of Rockefeller**, New York City, December 2015

         University of Trento, Italy, Rovereto Attention Workshop, November 2015

         Ernst Strungmann Institute for Neuroscience, Germany, "Brain Codes" Conference, June 2015

         Banbury Center at Cold Spring Harbor Laboratory, NIMH Sponsored Conference, "Brain Rhythms as Potential Targets for Intervention in Cognitive Dysfunctions", March 2015

         UT Austin, Imaging Research Center, January 2015

2014   **Cold Spring Harbor Laboratory**, "Connections and Communications in the Brain", Banbury Center

         Oxford University, Work on the nature and function of neural oscillations

         Queens College, City of New York, December 2014

2013   **22nd Annual Computational Neuroscience Meeting;** Workshop on "Neural mechanisms of working memory limits", Paris, France; July 2013

         Oxford University; Oxford, England; July 2013

         Task-Driven Control of Thought and Action by Working Memory: Linking Mind and Brain; Conference at Beilefeld University, Bielefeld, Germany; June 2013

         Princeton University; NIAM Lecture Series, Princeton, NJ; May 2013

         Harvard University; Psychology Department, Cambridge, MA; February 2013

2012   **Visual Search and Selective Attention**; Conference, Munich, Germany; July 2012

         University of Tubingen; Tubingen, Germany; July 2012

         Harvard University, Visual Attention Lab, Cambridge, MA

         California Institute of Technology, Pasadena, CA; March 2012

         Princeton University, Princeton, NJ; March 2012

         Stanford University, School of Medicine, Palo Alto; February 2012

         New York University, New York, NY; January 2012

         University of Wisconsin, Madison, Madison, WI; January 2012

2010   **Dynamics of Cortico-Cortical Interactions**, Chico, MT

         Workshop on Computational Properties of Prefrontal Cortex, Vancouver, BC Canada

2009   **Harvard University**, Visual Attention Lab, Cambridge, MA

2008   **NSF Science of Learning Annual Meeting**, Washington, DC

Abstracts, Poster Presentations and Exhibits Presented at Professional Meetings

2018   **A flexible model of working memory**
Talk at Cosyne, 2018
Bouchacourt F, **Buschman TJ**

The neural circuit basis of feature-binding in working memory
Cosyne, 2018
Barbosa J, Temudo A, Babushkin V, **Buschman TJ**, Sreenivasan K, Compte A

Cortical network graphs and dynamic functional connectivity in a mouse model of autism spectrum disorder
Society for Neuroscience Annual Meeting, 2018
MacDowell CJ, **Buschman TJ**

Navigating in neural and behavioral manifolds with closed-loop multi-site electrical microstimulation system
Society for Neuroscience Annual Meeting, 2018
Tafazoli S, MacDowell CJ, Letai K, Che D, **Buschman TJ**

A flexible model of working memory
Talk at Society for Neuroscience Annual Meeting, 2018
Bouchacourt F and **Buschman TJ**

Intrinsic neuronal dynamics predict distinct functional roles during working memory
Society for Neuroscience Annual Meeting, 2018
Wasmuht DF, Spaak E, **Buschman TJ**, Miller EK, Stokes MG

2017   **Compression of information in visual working memory**
Society for Neuroscience Annual Meeting, 2017
Kollias P, **Buschman TJ**

Control mechanisms for flexibility in a changing world
Society for Neuroscience Annual Meeting, 2017
Ebitz BA, Cohen JD, **Buschman TJ**

Memory load modulates the dynamics of visual working memory
Society for Neuroscience Annual Meeting, 2017
Panichello MF, DePasquale BD, Pillow JW, **Buschman TJ**

A Bayesian approach to inferring latent connectivity patterns from spike trains reveals that working memory maintenance induces rapid synaptic plasticity
Society for Neuroscience Annual Meeting, 2017
Spaak E, Constantinidis C, Duncan J, **Buschman TJ**, Miller EK, Stokes MG

Learning sound sequences in mouse auditory cortex
Society for Neuroscience Annual Meeting, 2017
Libby AG, **Buschman TJ**

Memory through randomness: A spiking network model for flexible working memory
Society for Neuroscience Annual Meeting, 2017
Bouchacourt F, **Buschman TJ**

Navigating in neural and behavioral manifolds with mutli-site electrical microstimulation
Society for Neuroscience Annual Meeting, 2017
Tafazoli S, Letai K, **Buschman TJ**

Bottom-up salience drives choice during exploration
Cosyne, 2017
Ebitz B, Moore T, **Buschman TJ**

2016   **Altered balance between top-down and bottom-up saccadic control across exploration and exploitation**
Society for Neuroscience Annual Meeting, 2016
Ebitz RB, Moore T, **Buschman TJ**

Generating complex neural patterns with multi-site electrical microstimulation
Society for Neuroscience Annual Meeting, 2016
Tafazoli S, **Buschman TJ**

The neural basis of dynamic coding in prefrontal cortex during a spatial working memory task
Society for Neuroscience Annual Meeting, 2016
Spaak E, Wasmuht D, **Buschman TJ**, Miller EK, Stokes M

Pinging the brain reveals hidden states for working memory guided behavior
Society for Neuroscience Annual Meeting, 2016
Wolff M, Jochim J, **Buschman TJ**, Akyurek EG, Stokes MG

Working memory load may modulate neuronal coupling
Society for Neuroscience Annual Meeting, 2016
Pinotsis, D, **Buschman TJ**, Miller EK

2014   **Modulation of power and synchrony of local field potentials by working memory load in the macaque**
Society for Neuroscience Annual Meeting, 2014
Kornblith S, **Buschman TJ**, Miller EK

2013   **Probing interactions between distinct cortical microcircuits through spatiotemporally patterned 3-D optogenetics**
Society for Neuroscience Annual Meeting, 2013
Zorzos AN, **Buschman TJ**, Monahan PE, Scholvin J, Fonstad C, and Boyden ES

Contributions of prefrontal cortical areas during task switching
Society for Neuroscience Annual Meeting, 2013
Denovellis EL , **Buschman TJ**, Bullock D, Miller EK

2012   **Dynamic, synchronous, sub-networks in prefrontal cortex encode stimulus-response rules**
Society for Neuroscience Annual Meeting, 2012
Buschman TJ, Denovellis EL, Diogo C, Bullock D, Miller EK

Point process models of anterior cingulate and dorsolateral prefrontal cortical neurons during cognitive control
Society for Neuroscience Annual Meeting, 2012
Denovellis EL , **Buschman TJ**, Diogo C, Bullock D, Miller EK

Prefrontal cortex neurons reflect decisions about ambiguous stimuli.
Society for Neuroscience Annual Meeting, 2012
Roy JE, **Buschman TJ**, Miller EK

Neural recoding from the prefrontal network during the update of working memory
Society for Neuroscience Annual Meeting, 2012
Rose JM, **Buschman TJ**, Miller EK

In vivo optogenetic neural circuit control using 3-D microfabricated optical waveguide arrays
Society for Neuroscience Annual Meeting, 2012
Zorzos AN, Monahan PE, **Buschman TJ**, Scholvin J, Acker L, Fonstad CG, Boyden ES

Dynamic networks in frontal cortex support the cognitive flexibility to switch between rules
Computational and Systems Neuroscience (Cosyne) 2012
Buschman TJ, Denovellis EL, Diogo C, Bullock D, Miller EK

Neural recoding from the prefrontal network during the update of working memory
8th Federation of European Neuroscience Societies (FENS) Forum of Neuroscience
Rose J, **Buschman TJ**, Miller EK

2011   **Investigating cortico-cortical interactions in the mouse somatosensory system using electrophysiological and optogenetic techniques**
Society for Neuroscience Annual Meeting
Buschman TJ, Voigts J, Siegle J, Vierling-Classen D, Moore CI

Tasking Switching in the Prefrontal and Anterior Cingulate Cortex
Society for Neuroscience Annual Meeting
Denovellis EL, **Buschman TJ**, Diogo C, Bullock D, Miller EK

Evidence from Capacity Limitations for a Dual-Model of Working Memory
Society for Neuroscience Annual Meeting
Rose J, **Buschman TJ**, Yorgan VR, Miller EK

2010 **Neural Correlates of Working Memory Capacity Limitations in Primate Prefrontal and Parietal Cortices**
Society for Neuroscience Annual Meeting
Buschman TJ, Yorgan V, Siegel M, and Miller EK

2008 **The Role of Synchrony and Oscillations in the Control of Visual Attention in Monkey Cortex**
Society for Neuroscience Annual Meeting
Buschman TJ and Miller EK

2007 **Shared and Distinctive Mechanisms in Primate Frontal and Parietal Cortex During Internal and External Control of Attention**
Society for Neuroscience Annual Meeting
Buschman TJ and Miller EK

2006 **Comparison of AND, OR, and XOR rules in monkeys**
Society for Neuroscience Annual Meeting
Buschman TJ, Machon M, and Miller EK

2005 **Roles of monkey prefrontal and parietal cortices in exogenous and endogenous control of visual attention**
Society for Neuroscience Annual Meeting
Buschman TJ and Miller EK

2004 **Different timecourses for visual target selection in the monkey prefrontal vs. parietal cortex**
Society for Neuroscience Annual Meeting
Buschman TJ and Miller EK

2002 **Modulation of neuronal synchronization in area V2 by selective visual attention**
Society for Neuroscience Annual Meeting
Buffalo EA, **Buschman TJ**, Fries P, Desimone R

Teaching

2018-19, Spring; 2017-18, Spring;	"From Molecules to Systems to Behavior", NEU 502A/MOL 502A, Princeton Neuroscience Institute, Princeton University.
2018-19, Fall; 2016-17, Fall; 2015-16, Spring	"Cognitive Neuroscience of Selective Attention", PSY 316/NEU 316, Psychology Department and Neuroscience Concentration, Princeton University.
2014-15, Fall	"Cellular and Systems Neuroscience", NEU 408/MOL 408/PSY 404, Psychology Department and Neuroscience Certificate Program, Princeton University.
2013-14, Spring	"Neural Dynamics and Their Role in Cognition", NEU/PSY 422/522, Psychology Department and Neuroscience Certificate Program, Princeton University.
2011, Fall	Guest lecturer on "Basal Ganglia and the Prefrontal Cortex: From Habits to Cognition" in PGY2 Clinical Neuroscience Lecture Series, MGH.
2011, Fall	Guest lecturer on "Working Memory and Executive Control" in Neural Basis of Learning and Memory, 9.03, Undergraduate Course, MIT.
2005-2006, Fall	Teaching Assistant for 9.011, Introductory to Systems Neuroscience Graduate Course, Dept. Brain and Cognitive Science at MIT.
2004, Spring	Teaching Assistant for 9.02, Undergraduate Brain Lab in Dept. Brain and Cognitive Sciences at MIT.