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Personal

Born 7.7.70, raised in Morgantown, WV
Married to Sharon L. Botnovcan, four children

Professional Positions

- 2016— , Professor, Department of Psychological and Brain Sciences, Boston University
- 2011—2016, Associate Professor, Department of Psychological and Brain Sciences, Boston University
- 2008—2011, Associate Professor, Department of Psychology, Syracuse University
- 2004—2011, Courtesy appointment, Biomedical and Chemical Engineering, Syracuse University
- 2002—2008, Assistant Professor, Department of Psychology, Syracuse University

Education

- 2001-2002 Postdoctoral Fellow, Department of Psychology, Boston University, Michael Hasselmo, advisor, Computational neuroscience.
- 1999-2001 Postdoctoral Fellow, Department of Psychology, Brandeis University, Michael Kahana, advisor, Cognitive neuroscience.
- 1999 Ph.D., Brandeis University, Neuroscience; Thesis: *Temporal context in human memory*, Michael Kahana, chair.
- 1992 B.A., Rutgers University, Physics, Magna Cum Laude.
- Also attended: West Virginia University, Raritan Valley Community College, New School for Social Research.

Publications [Google Scholar Citation Report]

- Howard, M. W., Shankar, K. H., and Tiganj, Z. (2015). Efficient neural computation in the Laplace domain. In Tarek R. Besold, Artur d'Avila Garcez, Gary F. Marcus, Risto Miikulainen (eds.): *Proceedings of the NIPS 2015 workshop on Cognitive Computation: Integrating Neural and Symbolic Approaches.* Montréal, Canada, 2015.

- Shankar, K. H., Singh, I., and Howard, M. W. (2015). Neural mechanism to simulate a scale-invariant future. arXiv:1503.03322
- Howard, M. W., and Eichenbaum, H. (2015). Time and space in the hippocampus, *Brain Research*. **1621**, 345-354. doi:10.1016/j.brainres.2014.10.069
- Howard, M. W., Shankar, K. H., Aue, W. R., and Criss, A. H. (2015). A distributed representation of internal time, *Psychological Review*. **122**, 24-53. doi://10.1037/a0037840
- Criss, A. H. and Howard, M. W. (2015). Episodic memory. In *Oxford Handbook of Computational and Mathematical Psychology*, J. R. Busemeyer, J. T. Townsend, Z. J. Wang, and A. Eidels (Eds.). Oxford University Press.
- Tiganj, Z., Hasselmo, M. E., and Howard, M. W. (2015). A simple biophysically plausible model for long time constants in single neurons, *Hippocampus*, **25**, 27-37. doi://10.1002/hipo.22347
- Howard, M. W., MacDonald, C. J., Tiganj, Z., Shankar, K. H., Du, Q., Hasselmo, M. E., and Eichenbaum, H. (2014). A unified mathematical framework for coding time, space, and sequences in the hippocampal region. *Journal of Neuroscience*, **34**, 4692-707.
- Howard, M. W. (2014). Mathematical learning theory through time. *Journal of Mathematical Psychology*, **59**, 18-29.
- Shankar, K. H. and Howard, M. W. (2013). Optimally fuzzy scale-free memory. *Journal of Machine Learning Research*. **14**, 3753-3780.
- Howard, M. W., and Eichenbaum, H. (2013). The hippocampus, time and memory across scales, *Journal of Experimental Psychology: General*, **142**, 1211-1230.
- Komorowski, R. W., Garcia, C. G., Wilson, A., Hattori, S., Howard, M. W., and Eichenbaum, H. (2013). Ventral hippocampal neurons are shaped by experience to represent behaviorally relevant contexts. *Journal of Neuroscience*, **33**, 8079–8087.
- Kılıç, A., Hoyer, W. J., and Howard, M. W. (2013). Effects of Spacing of Item Repetitions in Continuous Recognition Memory: Does Item Retrieval Difficulty Promote Item Retention in Older Adults? *Experimental Aging Research*, **39**, 322–341.
- Kılıç, A., Criss, A. H., and Howard, M. W. (2013). A causal contiguity effect that persists across time scales, *Journal of Experimental Psychology: Learning, Memory and Cognition*, **39**, 297–303.
- Howard, M.W., Viskontas, I.V., Shankar, K.H., and Fried, I. (2012). Ensembles of human MTL neurons "jump back in time" in response to a repeated stimulus, *Hippocampus*, **22**, 1833–1847.
- Shankar, K. H., and Howard, M. W. (2012). A scale-invariant internal representation of time, *Neural Computation*, **24**, 134–193.
- Howard, M. W., Shankar, K. H., and Jagadisan, U. K. K. (2011). Constructing semantic representations from a gradually-changing representation of temporal context. *Topics in Cognitive Science*, **3**, 48-73. doi:10.1111/j.1756-8765.2010.01112.x.

- Shankar, K. H., and Howard, M. W. (2010). Timing using temporal context, *Brain Research*, **1365**, 3-17 (lead article). doi:10.1016/j.brainres.2010.07.045.
- Sederberg, P. B., Miller, J. F., Howard, M. W., and Kahana, M. J. (2010). The temporal contiguity effect predicts episodic memory performance. *Memory & Cognition*, **38**, 689-699.
- Onyper, S. V., Zhang, Y., and Howard, M. W. (2010). Some-or-none recollection: Evidence from item and source memory. *Journal of Experimental Psychology: General*, **139**, 341-364.
- Shankar, K. H., Jagadisan, U. K. K., and Howard, M. W. (2009). Sequential learning using temporal context. *Journal of Mathematical Psychology*, **53**, 474-485.
- Howard, M. W., Sederberg, P. B., and Kahana, M. J. (2009). Reply to Farrell & Lewandowsky: Recency-contiguity interactions predicted by the temporal context model. *Psychonomic Bulletin & Review*, **16**, 973-984.
- Howard, M. W., Jing, B., Rao, V. A., Provyn, J. P., & Datey, A. V. (2009). Bridging the gap: Transitive associations between items presented in similar temporal contexts. *Journal of Experimental Psychology: Learning, Memory & Cognition*, **35**, 391-407.
- Howard, M. W. (2009). Memory: Computational models. in L. R. Squire (Ed), *New Encyclopedia of Neuroscience*, volume 5, pp. 771-777. Oxford: Academic Press.
- Howard, M. W., Kahana, M. J., and Sederberg, P. B., (2008). Postscript: Distinguishing between temporal context and short-term store. *Psychological Review*, **115**, 1125-6 .
- Kahana, M. J., Sederberg, P. B., and Howard, M. W. (2008). Putting short-term memory into context: Reply to Usher, Davelaar, Haarman and Goshen-Gottstein (2008). *Psychological Review*, **115**, 1119-1126.
- Sederberg, P. B., Howard, M. W., and Kahana, M. J. (2008). A context-based theory of recency and contiguity in free recall. *Psychological Review*, **115**, 893-912.
- Rao, V. A. and Howard, M. W. (2008). Retrieved context and the discovery of semantic structure. *Advances in Neural Information Processing Systems 20*, J.C. Platt, D. Koller, Y. Singer and S. Roweis, Eds. MIT Press: Cambridge, MA.
- Kahana, M. J., Howard, M. W., & Polyn, S. M. (2008). Associative retrieval processes in episodic memory. In, H. L. Roediger, (Ed), *Learning and Memory - A Comprehensive Reference*, Academic Press, Oxford, pp. 467–490.
- Howard, M. W., Youker, T. E., and Venkatadass, V. (2008). The persistence of memory: Contiguity effects across several hundred seconds. *Psychonomic Bulletin & Review*, **15**, 58-63.
- Provyn, J. P., Sliwinski, M. J. & Howard, M. W. (2007). Effects of age on contextually mediated associations in paired associate learning. *Psychology and Aging*, **22**, 846-857.
- Manns, J. R., Howard, M. W., & Eichenbaum, H. B. (2007). Gradual changes in hippocampal activity support remembering the order of events, *Neuron*, **56**, 530-540.

- Howard, M. W., Venkatadass, V., Norman, K. A., and Kahana, M. J. (2007). Associative processes in immediate recency. *Memory & Cognition*, **35**, 1700-1711.
- Howard, M. W., Addis, K. A., Jing, B. and Kahana, M. J. (2007), Semantic structure and episodic recall, in Landauer, McNamara, Dennis, & Kintsch (Eds) *Handbook of Latent Semantic Analysis*, Laurence Erlbaum Associates: Mahwah, NJ, pp. 121-141.
- Siekmeier, P. J., Hasselmo, M. E., Howard, M. W., and Coyle, J. T. (2007). Modeling of context dependent retrieval in hippocampal region CA1: Implications for cognitive function in schizophrenia. *Schizophrenia Research*, **89**, 177-190.
- Zaromb, F. M., Howard, M. W., Dolan, E. D., Sirotin, Y. B., Tully, M., Wingfield, A. and Kahana, M. J. (2006). Temporally-based false memories in free recall. *Journal of Experimental Psychology: Learning, Memory and Cognition*, **32**, 792-804.
- Howard, M. W., Wingfield, A. and Kahana, M. J. (2006). Aging and contextual binding: Modeling recency and lag-recency effects with the temporal context model, *Psychonomic Bulletin & Review*, **13**, 439-445.
- Howard, M. W., Bessette-Symons, B. A., Zhang, Y., and Hoyer, W. J. (2006). Aging selectively impairs recollection in recognition memory for pictures: Evidence from modeling and ROC curves, *Psychology and Aging*, **21**, 96-106.
- Howard, M. W. and Natu, V. S. (2005). Position from time: Spatial precision in the temporal context model, *Neural Networks*, **18**, 1150-1162.
- Schwartz, G., Howard, M. W., Jing, B., and Kahana, M. J. (2005). Shadows of the past: Temporal retrieval effects in recognition memory, *Psychological Science*, **16**, 898-904.
- Kahana, M. J. and Howard, M. W. (2005). The spacing and lag effect in free recall, *Psychonomic Bulletin & Review*, **12**, 159-164.
- Howard, M. W., Fotedar, M. S., Datey, A. V. and Hasselmo, M. E. (2005). The temporal context model in spatial navigation and relational learning: Toward a common explanation of medial temporal lobe function across domains, *Psychological Review*, **112**, 75-116.
- Howard, M. W.(2004). Scaling behavior in the temporal context model, *Journal of Mathematical Psychology*, **48**, 230-238.
- Sederberg, P. B., Kahana, M. J., Howard, M. W., Donner, E., and Madsen, J. R. (2003). Theta and gamma oscillations during encoding predict subsequent recall, *Journal of Neuroscience*, **23**, 10809-14.
- Howard, M. W., Rizzuto, D. S., Madsen, J. R., Lisman, J. E., Aschenbrenner-Scheibe, R., Schulze-Bonhage, A. and Kahana, M. J. (2003). Gamma oscillations correlate with working memory load in humans, *Cerebral Cortex*, **13**, 1369-1374.
- Sherman, S. J., Atri, A., Hasselmo, M. E., Stern, C. E. and Howard, M. W. (2003). Scopolamine impairs human recognition memory: Data and modeling. *Behavioral Neuroscience*, **117**, 526-539.

- Kahana, M. J., Howard, M. W., Zaromb, F. M., and Wingfield, A. (2002). Age dissociates recency and lag-recency effects in free recall. *Journal of Experimental Psychology: Learning, Memory and Cognition*, **28**, 530-540.
- Howard, M. W. and Kahana, M. J. (2002). A distributed representation of temporal context. *Journal of Mathematical Psychology*, **46**, 269-299.
- Howard, M. W. and Kahana, M. J. (2002). When does semantic similarity help episodic retrieval? *Journal of Memory and Language*, **46**, 85-98.
- Howard, M. W. and Kahana, M. J. (1999). Contextual variability and serial position effects in free recall. *Journal of Experimental Psychology: Learning, Memory and Cognition*, **25**, 923-941.

Working papers

- Tiganj, Z., Shankar, K. H., and Howard, M. W. (submitted). Neural mechanism for scale-invariant frequency decomposition.
- Singh, I., Oliva, A., and Howard, M. W. (in revision). Visual memories are stored on a logarithmically-compressed representation of the past.
- Tiganj, Z., Kim, J., Jung, M. W., and Howard, M. W. (in revision). Temporal coding across scales in the rodent mPFC.

Patents

- A METHOD FOR CONSTRUCTING A SCALE-INVARIANT MEMORY BUFFER, U.S. Provisional Patent Application No. 62/048,091 (with Karthik Shankar and Zoran Tiganj).

Current Support

- co-Investigator, Initiative for Physics and Mathematics of Neural Systems, NSF EAGER Program (M. Hasselmo PI).
- Subcontract Principal Investigator, Memory Enhancement with Modeling, Electrophysiology, and Stimulation (MEMES), DARPA Restore Active Memory (RAM) program, 7/1/2014–6/30/2019, (M. Kahana project P.I.), BU subcontract $1.2M.
- Principal Investigator, Sequential learning from a scale-invariant representation of remembered time, NSF award BCS-1058937, 1/15/2012–12/31/2015, $366,567 total costs.

Completed Support

- Principal Investigator, A distributed representation of space and time, AFOSR FA9550-12-1-0369, 7/1/2012–6/30/2015, $390,754 total costs.
- Principal Investigator, A distributed representation of remembered time, AFOSR FA9550-10-1-0149, 5/1/2010–4/30/2012, $264,907 total costs.

- Principal Investigator, Retrieved Context in Episodic and Semantic Memory, 1-R01 MH069938-01, 2/1/2004–1/31/2010. $770,000 in direct costs (initial budget).
- Principal Investigator, Toward the neural basis of episodic memory. 1F32 MH65841-01 (Individual NRSA). Michael Hasselmo, sponsor. 01/02—01/05. $145,000 (terminated early to accept faculty position).

Awards

- 2004 Society for Mathematical Psychology New Investigator Award.
- Knight of the Golden Horseshoe

Recent Invited Talks

- Rutgers University Center for Cognitive Science, October 2015.
- MIT, Center for Minds, Brains, and Machines, May 2015.
- Columbia, Center for Theoretical Neuroscience, Feb 2015.
- BU, Center for Systems Neuroscience and Initiative for Physics and Mathematics of Neural Systems, December 2014.
- AFOSR Investigators Meeting, Washington, D.C., November 2014.
- University of Massachussetts, Amherst, August 2014.
- University of Pennsylvania, July 2014.
- Syracuse University, Cognition, Brain & Behavior Proseminar, May 2014.
- AFOSR Investigator's meeting, Washington, D.C., Jan. 2014.

Professional Activities

- Associate Editor, *Psychonomic Bulletin & Review*, 2014—
- Editorial board, *Psychological Review*, 2015—; *Journal of Mathematical Psychology*, 2010—; *Psychonomic Bulletin & Review*, 2008—2013; *Frontiers in Cognition*, 2010—2013;
- NSF grant review: College of Reviewers Perception, Action & Cognition, Science of Learning Centers Site Visit Team (multiple times), National Research Training (NRT), Collaborative research in computational neuroscience (CRCNS)
- Other grant review: AFOSR, Netherlands Organization for Scientific Research, Israeli Science Foundation, Marsden Fund (New Zealand), NIMH B/Start mechanism, Department of Education Program on Research in Reading Comprehension review panel
- Founding program director, Syracuse University Integrated Learning Major in Neuroscience, 2010–2011

- Area Director, Syracuse University Cognition, Brain & Behavior graduate training program, 2010–2011
- Co-founder of SNO, the Syracuse Neuroscience Organization (http://sno.syr.edu).
- Member, Society for Neuroscience, American Psychological Society, Psychonomic Society, Society for Mathematical Psychology

Teaching and Mentoring

- Undergraduate courses: Human Memory, Cognitive Psychology, Cognitive Neuroscience, Honor's course "Towards a Physics of the Mind,"
- Graduate courses: Computational Methods for Experimental Psychology; Cognitive Neuroscience of Memory; Memory and Attention; Memory Systems of the Brain; Time and Memory; Human Memory: Theory and Data.
- Postdoctoral advisees
  - Karthik Shankar (Theoretical Physics PhD), 2007—
  - Zoran Tiganj (Neural engineering PhD), 2013—
- Ph.D. students:
  - Nathanael Cruzado (BU Neuroscience, BS EE & Math), 2015—
  - Joe DiLascio (BU Neuroscience, BS Physics & Philosophy), 2014—
  - Inderdeep Singh (BU Brain, Behavior and Cognition, BS BME), 2012—
  - Jennifer Provyn, (Syracuse, 2013), Children's Mercy Hospital, Kansas City
  - Asli Kılıç (Syracuse, 2012, Dissertation advisor Amy Criss), Assistant Professor (tenure-track), Mid-East Technical University
  - Brandy Bessette-Symons (Syracuse 2008), Assistant Professor (tenure-track), Ithaca College
  - Serge Onyper (Syracuse 2007), Associate Professor, St. Lawrence University
- M.S. students
  - Vinayak Rao (Syracuse EE), Computational Neuroscience PhD, Gatsby, University College London; Assistant Professor, Department of Statistics, Purdue
  - Vaidehi Natu (Syracuse EE), Psychology PhD UT-Dallas, Post-doc with Kalanit Grill-Spector at Stanford
  - Yaofei Zhang (Syracuse Psych), AVP at JPMorgan Chase
  - Aditya Datey (Syracuse CE), VP at JPMorgan Chase
  - Mrigankka Fotedar (Syracuse CS), Microsoft
  - Udaya Jagadisan (Syracuse BME), PhD student, Biomedical Engineering, University of Pittsburgh
  - Sridhar Iyer (Syracuse CS), Cisco Systems.

- Undergraduate students (selected)
  - Donna Bridge, PhD, Research Assistant Professor, Northwestern University
  - Seth Elkin-Frankston, PhD; Research position at Charles River Analytics
  - Clarion Mendes, MA, Clinical Instructor/Speech-Language Pathologist at UIUC