OMB No. 0925-0001/0002 (Rev. 08/12 Approved Through 8/31/2015)

BIOGRAPHICAL SKETCH

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| NAME: Manning, Jeremy R. |
| eRA COMMONS USER NAME (agency login): MANNINGJ |
| POSITION TITLE: Assistant Professor of Psychology |

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable.)*

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| INSTITUTION AND LOCATION | DEGREE (if applicable) | Completion Date  MM/YYYY | FIELD OF STUDY |
| Brandeis University, Waltham, MA | BS | 05/2006 | Neuroscience, Computer Science |
| University of Pennsylvania, Philadelphia, PA | PHD | 05/2011 | Neuroscience |
| Princeton University, Princeton, NJ | Postdoctoral Fellow | 07/2015 | Neuroscience, Computer Science |

### A. Personal Statement

I am broadly interested in how the ways our brains acquire, process, store, and retrieve information are affected by the current context or situation. My primary research program is centered on how we encode and retrieve episodic (autobiographical) memories. For example, I ask questions like “how do our past experiences affect how we perceive what is happening now,” “how does what is happening now affect how we remember this moment later,” or “how does what is happening now affect what memories spontaneously come to mind?” I use computational models, behavioral experiments, and neuroimaging techniques (fMRI, EEG, ECoG) to gain insights into these questions and processes. In addition to elucidating the neural mechanisms underlying memory and context and developing formal theories of memory, my work has direct implications for treating memory disorders (e.g. Alzheimer’s, PTSD) and for developing training programs that leverage real-time neurofeedback to help (healthy and impaired) individuals to learn as quickly and efficiently as possible. To this end, the current application supports my research program by furthering our understanding of memory dysfunction in epilepsy patients, and how healthy memory function might be restored in these individuals.

**Four most relevant publications:**

1. Manning J, Polyn S, Baltuch G, Litt B, Kahana M. Oscillatory patterns in temporal lobe reveal context reinstatement during memory search. Proceedings of the National Academy of Sciences. 2011; 108(31):12893-12897.
2. Manning J, Sperling M, Sharan A, Rosenberg E, Kahana M. Spontaneously Reactivated Patterns in Frontal and Temporal Lobe Predict Semantic Clustering during Memory Search. Journal of Neuroscience. 2012; 32(26):8871-8878.
3. Manning J, Lew T, Li N, Sekuler R, Kahana M. MAGELLAN: A cognitive map–based model of human wayfinding. Journal of Experimental Psychology: General. 2014; 143(3):1314-1330.
4. Manning J, Ranganath R, Norman K, Blei D. Topographic Factor Analysis: A Bayesian Model for Inferring Brain Networks from Neural Data. PLoS ONE. 2014; 9(5):e94914.

### B. Positions and Honors

Positions and Employment

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| 2011 - 2015 | Postdoctoral Research Associate, Princeton University, Princeton Neuroscience Institute and Department of Computer Science, Princeton, NJ |
| 2015 - | Assistant Professor of Psychology, Dartmouth College, Hanover, NH |

Honors

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| 2006 | Systems and Integrative Biology Training Grant, NIH |
| 2008 | Computational Neuroscience Training Grant, NIH |
| 2010 | Ruth L. Kirshstein National Research Service Award for an Individual Predoctoral Fellowship, NIMH |

### C. Contribution to Science

1. One major scientific contribution of my work has been to further our understanding of the relation between single-neuron action potentials and population (local field) activity in humans. The dominant view in the human electrocorticography literature has been that single-neuron action potentials are best characterized by high frequency (gamma band) spectral changes in the local field potential. I undertook a systematic study of rare simultaneous single-neuron and population recordings taken from human neurosurgical patients. I found that, somewhat surprisingly, broadband (non-oscillatory) changes in the local field potential were a much stronger correlate of single-neuron firing than were oscillatory changes (including in the gamma band). My Journal of Neuroscience paper reporting these results has since been cited over 200 times in the 5 years since its publication, and many of these citations are from papers that have carried out direct follow-up studies of this work.
   1. Manning J, Jacobs J, Fried I, Kahana M. Broadband Shifts in Local Field Potential Power Spectra Are Correlated with Single-Neuron Spiking in Humans. Journal of Neuroscience. 2009 October 28; 29(43):13613-13620.
2. Another major contribution of my work has been to expand our understanding of how episodic (autobiographical) memories are encoded and retrieved by our brain's memory systems. A fundamental historical intuition held by philosophers and psychologists such as Aristotle, Hume, James, and others has been that our experiences are "tagged" using the ever-changing stream of contextual cues that defines our subjective experience. For example, hearing a particular song on your way to work might remind you of another time you heard the same song years ago, which might in turn dredge up other related information (where you were, who you were with, etc.). Despite an extensive behavioral and computational literature hypothesizing a central role for contextual information in how we encode and retrieve autobiographical memories, prior to my work there had been no direct neural evidence for such representations. I carried out a series of studies using data from human neurosurgical patients who volunteered to study and recall lists of randomly chosen words. I used computational models to isolate neural patterns that behaved like contextual representations, and studied these representations as the patients encoded and retrieved memories. This framework allowed me to directly observe the neural basis of these contextual representations, and the role they play in memory encoding and retrieval.
   1. Manning J, Polyn S, Baltuch G, Litt B, Kahana M. Oscillatory patterns in temporal lobe reveal context reinstatement during memory search. Proceedings of the National Academy of Sciences. 2011; 108(31):12893-12897.
   2. Manning J, Sperling M, Sharan A, Rosenberg E, Kahana M. Spontaneously Reactivated Patterns in Frontal and Temporal Lobe Predict Semantic Clustering during Memory Search. Journal of Neuroscience. 2012; 32(26):8871-8878.
   3. Manning J, Kahana M. Interpreting semantic clustering effects in free recall. Memory. 2012; 20(5):511-517.
3. A third contribution of my work relates to how patterns of interactions (connectivity) across brain regions reflects ongoing cognitive processes. Standard approaches to examining how patterns of brain connectivity reflect cognition entail computing functional connections between every pair of observed measurements. For example, standard functional connectivity approaches to fMRI data entail computing the correlation between every pair of voxel time series. The number of computations required to relate these full brain functional connectivity patterns to cognitive states can become prohibitive. Further, computing full brain voxel-by-voxel connectivity matrices effectively treats each voxel as independent, even though it is well known that brain data exhibit strong spatial correlations. I have developed a probabilistic modeling approach for looking at brain connectivity patterns in a much more mathematically compact way. The general approach involves re-representing patterns of brain activity using a relatively small number of network "hubs" distributed throughout the brain. This turns connectivity analysis into an optimization problem: given a brain dataset, we must compute the most probable number of network hubs, where the hubs go in the brain, how big the hubs are, and how the hubs are connected to each other at each moment in time during an experiment. Because most neuroimaging datasets may be adequately described by on the order of a few hundred network hubs, this reduces the computational complexity of analyses of connectivity patterns by several orders of magnitude.
   1. Manning JR, Ranganath R, Norman KA, Blei DM. Topographic factor analysis: a Bayesian model for inferring brain networks from neural data. PLoS One. 2014;9(5):e94914.
   2. Manning J, Ranganath R, Keung W, Turk-Browne N, Cohen J, Norman K, Blei D. Hierarchical topographic factor analysis. 2014 International Workshop on Pattern Recognition in Neuroimaging. 2014 International Workshop on Pattern Recognition in Neuroimaging (PRNI); IEEE; c2014.
4. A fourth contribution of my work relates to our understanding of how our memory systems encode, organize, and retrieve spatial information. For example, how do we build up useful representations of novel environments? Or how do we use our existing knowledge to explore efficiently? Electrophysiological studies in animals and humans over the past half-century have led to the discovery of networks of navigationally relevant neuronal populations, such as place cells and grid cells (which respond preferentially when an animal is located in a particular place), head direction cells (which respond preferentially when an animal is headed in a particular direction), and others. These findings have inspired a number of low-level biologically detailed models of how the known neural machinery might support higher level cognitive representations. However, these low-level models are not intended to explain high-level navigation behaviors such as exploration strategies. Meanwhile, an extensive behavioral literature on navigating humans and non-human animals has inspired high-level descriptive models based on egocentric and allocentric spatial encoding strategies. These high-level models attempt to explain complex behaviors like exploration strategies, but do not attempt to connect these strategies to the underlying neural machinery. I undertook a major modeling effort to bridge these two spatial modeling literatures. The result was the MAGELLAN model of spatial navigation, which operates at the same high level as strategy-based models, but makes quantitative predictions about the way in which people build up mental representations of unfamiliar environments and use those representations to navigate efficiently.
   1. Manning J, Lew T, Li N, Sekuler R, Kahana M. MAGELLAN: A cognitive map–based model of human wayfinding. Journal of Experimental Psychology: General. 2014; 143(3):1314-1330.
5. A fifth contribution of my work is in the domain of color vision. I have developed a Bayesian framework for exploring how our visual systems form predictions about the visual world from observed photoreceptor responses. For example, at each location on our retinas, we may have a single rod or cone photoreceptor. Each photoreceptor class is maximally sensitive to a particular wavelength of light. (This is similar to the notion that a digital camera may have at most a single red, green, or blue sensor at each location on its sensory array.) Nonetheless, our subjective experience is that each point in space has an identifiable color that matches the objects in the environment rather than the placements of receptors on our retinas. This means that our visual systems must fill in the missing information. To explore the deeper theoretical properties of these processes, I build models of the visual world, retinal responses, and inference algorithms for reasoning and making predictions about the world given receptor responses. I then ask questions like: given some statistical facts about the visual world, how should we arrange our receptors to achieve the best expected prediction accuracies? Or, if we knew nothing about the statistical properties of natural images, or the identities (i.e., peak wavelength sensitivities) of the receptors on our retinae, under what physical conditions could our visual systems learn to see in color? In other words, how much knowledge must be "pre-programmed" into our visual systems, and how much can be learned through experience? This works applies the same sorts of contextual effects that dominate how we organize our memories to the much lower-level domain of color vision.
   1. Manning JR, Brainard DH. Optimal design of photoreceptor mosaics: why we do not see color at night. Vis Neurosci. 2009 Jan-Feb;26(1):5-19.
   2. Benson NC, Manning JR, Brainard DH. Unsupervised learning of cone spectral classes from natural images. PLoS Comput Biol. 2014 Jun;10(6):e1003652.

### D. Research Support

### Completed Research Support

2010/02/01-2011/05/31

5F31MH088118-02, National Institute of Mental Health

Jeremy Manning (PI)

The neural representation of context and its role in free recall

Role: PI