

# BIOENGINEERING SEMINAR

SPRING 2022

## Time as a Continuous Dimension in Natural and Artificial Networks

### Abstract

Neural representations of time are central to our understanding of the world around us. I review cognitive, neurophysiological and theoretical work that converges on three simple ideas. First, the time of past events is remembered via a population of neurons with a continuum of functional time constants. Second, these time constants evenly tile the time axis with a logarithmic mapping. This results in a neural Weber-Fechner scale for time. Third, these populations appear as dual pairs—one type of population contains cells that change firing rate monotonically over time and a second type of population that has circumscribed temporal receptive fields. Each of these populations represent what happened when in the past, but with different temporal basis functions and can be identified with the real Laplace transform of the past and an approximate inverse of that transform respectively. I review recent work showing that these ideas can be used to build artificial neural networks that have novel properties. Of particular interest, a convolutional neural network built using these principles can generalize to arbitrary rescaling of its inputs. That is, after learning to perform a classification task on a time series presented at one speed, it successfully classifies stimuli presented slowed down or sped up; the range of scales the network can generalize over goes up exponentially with memory and is independent of the number of weights. In addition to providing a foundation for many empirical results, these ideas can be used to develop useful technologies in the near term.

### Biography

Marc Howard was raised in Morgantown, WV. He studied a wide variety of topics before graduating with an undergraduate degree in physics from Rutgers University. At Brandeis University he worked on experiments and computational models of human episodic memory tasks in which people study and remember lists of words. As a post-doc at Boston University, he studied the computational neuroscience of memory. He started on the faculty at Syracuse University and later moved to Boston University where he is currently a professor of Psychological and Brain Sciences and (by courtesy) Physics.



### Marc Howard, PhD

Professor  
Psychological and Brain Sciences and  
Physics  
Boston University  
Boston, MA

**Thursday, March 24<sup>th</sup>**  
**12:00-1:00 pm**

Fairfax Campus:  
**Horizon Hall, Rm 2010**  
SciTech Campus:  
**Katherine Johnson Hall, Rm 258**

COVID protocol  
Please RSVP here:



Be sure to have green Mason  
COVID Health Check ready for  
entry.