Syllabus: PSYC 5564 Dynamics of Language and Cognition

This course explores recent work on oscillatory processes in the brain, natural language processing at the syntactic level, and dynamical systems work that potentially links the two.

Fall, 2018 University of Connecticut, Storrs
Mondays, 9-12 BOUS 162, Storrs

Instructor: Whitney Tabor, Office: BOUS 124
Email: whitney.tabor@uconn.edu
Office hours: Wednesdays 10-12

Last update: 2018-10-15 (Note: the syllabus will likely be adjusted as we proceed, in light of things learned along the way.)

Recommended texts:

Tools:
Matlab (+ Simulink?)

The work of the course
Weekly reading and/or problem sets
Project (short and sweet data analysis, analytic, or programming project)

Week 1 (August 27)
Intro: Oscillatory phenomena, grammatical phenomena, linking the two

Assignment 01: Read Luo & Poeppel (2007), Ding et al. (2015)

Week 2 (Sept 4-moved to Tuesday because of Labor Day) (Work due: Discuss Luo & Poeppel, Ding et al.)

Brain Oscillation Data: evidence for neural oscillation in relation to higher levels of language structure

Learn: Mathematical foundations for analysis of oscillatory processes

Assignment 02: Mathematical foundations
**Week 3 (Sept 10)**  (Work due: Assignment 02 Mathematical foundations)

Introduction to synchronization:

- Definition
- Measuring Phase and Frequency from a time series

Assignment 03 Synchronization: Tools for Analysis
  Read Pikovsky (2015) Chapters 1-2, 6 excerpt
  Exercises on Fourier transform (Extracting frequency-phase components) and Hilbert Transform (Instantaneous amplitude, phase, frequency of a signal)

**Week 4 (Sept 17)**  (Work due: Assignment 3 Synchronization: Tools for Analysis)

Intro to dynamical systems theory 1:
  1-d continuous systems
  Stability

Introduction to Synchronization:
  Autonomous oscillators

Assignment 04 Synchronization: Autonomous Oscillator
  1-d continuous dynamics
  Autonomous Oscillator

Read Pikovsky on Driven Oscillators

**Week 5 (Sept 24)**  (Work due: Assignment 4 Synchronization: Autonomous Oscillator)

Intro to Single Driven Oscillator

Assignment 05 Synchronization: Driven Oscillator

  Driven oscillator
  Ischrones

**Week 6 (Oct 1)**  (Work due: Assignment 5 Synchronization: Driven Oscillator)

Synchronization: Mutual Oscillators

Assignment 06 Synchronization: Mutual Oscillators (bidirectional coupling)

  Arnold Tongue
Reading: Pinker Excerpt from The Language Instinct on finite-state → context free argument (pp. 89-105)

**Week 7 (Oct 8)** (Work due: Assignment 6 Synchronization: Mutual Oscillators)

Introduction to discrete dynamical systems

Introduction to theories of syntax
Introduction to theory of computation

Assignment 07 Theory of Computation Intro

Finite State
Context Free

Reading: Elman (1990), Elman (1991) (excerpts)

**Week 8 (Oct 15)** (Work due: Intro to Symbolic Computation)

Theory of Computation overview: Chomsky Hierarchy
Introduction to parsing
- N-gram models
- PCFGs
Introduction to neural networks
- Feedforward
- Recurrent
  - Simple Recurrent Network

**Week 9 (Oct 22)**

Work Week (Whit away)

Assignment: revise previous homeworks

Start reading Nelson et al. (2017)

**Week 9 (Oct 29)**

Surprisal and neural network models of parsing
- Discussion of Levy (2008)

Development of discrete dynamical systems theory
Assignment:
  Read Nelson et al. (2017)
  Exercises on discrete dynamical systems

**Week 11 (Nov 5)** (Work due: Discrete Dynamical Systems)

Brain signatures of hierarchical parsing
  Nelson et al. (2017)
Iterated Function Systems

**Week 12 (Nov 12)** (Work due: Iterated Function Systems)

Finite-state processes generated by continuous dynamical systems

**Week 13 (Nov 26)** (Work due: fractal grammars, Poincare maps)

Putting the picture together: fractal grammars

**Week 14 (Dec 3)**

Putting the picture together: how grammatically driven, strobed continuous dynamical systems might give rise to brain wave patterns of some of the sorts reviewed up to now

Work due (a bit later): Final Project