RQA

Complex systems methods in the behavioural sciences

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Introduction

- In social sciences research, we usually treat variation in data as something to control for.
- Think of a typical ANOVA:
  1. We derive averages for our dependent variable. By estimating the expected value we aim to control for all variation in our signal.
  2. We divide our sample into groups, and aim to average out all variation caused by changes beyond our variables of interest.

Introduction

- This is a very effective research strategy. The experiment is the ultimate example!
  1. It allows us to make inferences about the average strength of the effect of a manipulation.
  2. It allows us to disentangle the effect on a dependent variable by a manipulation of independent variables between pre-defined groups.
- In short, a well-administered experimental or correlational study, is nothing to jeer at.

Dynamics

- But there are a lot of aspects that are difficult to capture by relying on aggregates.
  1. For example, how does mood fluctuate over the day?
  2. How does your pupil move to scan their visual field?
  3. How do people move through their environment?
  4. How do schizophrenic symptoms appear over time?
- These questions go into *dynamics*: the forces and motions that characterize a system.

Dynamics

- The "forces" that lead to a change in mood, or that decide how you scan the room with your eyes, are difficult to model or analyze:

  1. These forces are numerous.
  2. Interactions between these forces are numerous.
  3. Interactions between these forces are non-linear.
  4. It is impossible to infer the behaviour of the larger system by exclusively studying its components (*emergent* behaviour).

Complex Systems

- Systems like these are found in every applied research field, and seem to have a surprising number of common properties (and a larger number of differences).
- *Complex Systems* research is involved with studying the properties of systems where its behaviour is consistent with these properties (e.g., numerous elements, non-linear interactions, emergent properties).
- Do note that scientists do not agree on an exact formal definition.
- Complex systems tend to be intrinsically more difficult to study and model.

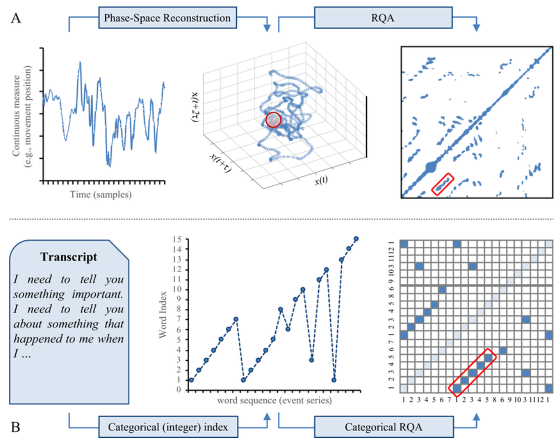
Recurrence Quantification Analysis

- There are many different methods to study the underlying dynamics of complex systems.
- But we'll focus on only one: Recurrence Quantification Analysis.
- This analysis is based on *recurrences*: the repetition of a point (within a certain radius) after x_{t+y}, where t refers to a time point of x and y .
- It allows us to infer *something* about the dynamics of a complex system from a single set of measurements.

Interpreting RQA's

- Different summary statistics:

  1. *Recurrence rate*: the proportion of cells in the matrix that are recurrent.
     - Says something about stationarity/periodicity etc.
  2. *Determinism*: proportion of recurrent points that form a diagonal line (a repeating series).
     - Says something about the predictability of the dataset.



- With these measures, we can quantify and visualize an aspect of the dynamics that are difficult to capture without these measures.

RQA & self-report scales

- Developments in research methods, such as ecological momentary assessment, allow for using time series with self-report scales.
- When doing research on mood, or other measures that use self-report, we have to rely on fairly infrequent measures, which means that the distance between two points of t can be high.
- We also tend to rely on *ordinal* scaling, which means we have fewer data points.
  - This is inherent to the self-report measure.

Research question

- I will perform a simulation study that aims to answer how sensitive these summary statistics are to course-graining and ordinalization.
  - I will use simulation methods for this.
  - I will also simulate a chaotic system that is highly sensitive to a change in initial variables (e.g., Lorentz System), and vary those variables (to create many different datasets).
  - I will start out with high resolution data.
  - I will then systematically decrease the data density.
  - I will then note the effects on different test conditions.

Tools

- Perhaps the julia-package for dynamical systems (DynamicalSystems.jl) or PyRQA, because they are known to be fast.
- I will perhaps develop some functions myself to perform the simulation.
- I will either simulate the dataset, or use existing data that has similar properties to self-report scales.