Simulating the potential of applying recurrence quantification analysis on ecological momentary assessment data

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Introduction

Ecological momentary assessment has made it possible to construct time series using self-report scales. Traditional statistical methods are often used to analyze time series, but these methods do not capture complex temporal patterns of those constructs over time (Jenkins et al. 2020).

While this type of data comes with its own set of challenges, there is also the potential to improve our understanding of the dynamics of psychological constructs. Recurrence quantification analysis is one of the methods to analyse time series data. This method aims to capture repeating patterns in time series by quantifying which observations x_{t+y} are equivelent to x_t, where t refers to the time of an observation, x to an observation, and y is the distance to t where that point recurs (Webber Jr and Zbilut 2005). The method results in several indicators statistics that can be used to understand patterns in the data.

Recurrence quantification measures were developed under the assumption that measurements can be retrieved at great frequency and at high resolution. However, measures in ecological momentary assessment rely on the admission of ordinal self-report questionnaires taken several times a day, limiting the set of possible states that the measuring device can capture. Moreover, the psychological constructs that are measured using EMA cannot be measured without relying on self-report questionnaires. This necessitates that research methods that are developed or adapted from the physical to the behavioural sciences take these particularities into account.

The current project

This project aims to find out at what point decreased data quality limits the ability of EMA to capture idiographic dynamics. We present an analysis pipeline consisting of multiple stages. We will use the `DynamicalSystems.jl` and `Statistics.jl` julia-packages to simulate the toy model and perform the analysis (Bezanson et al. 2017; Datseris 2018; Datseris and Parlitz 2022).

Stage 1: Data generation

In the first stage, we use a toy model developed to simulate the data based on a 3+1 dimensions model (Gauld and Depannemaecker 2023). This model captures clinical observations found in psychiatric symptomology by modeling internal factors, environmental noise, temporal specificities, and sympomatology. By changing these variables systematically, we aim to model a large variety of possible psychological constructs, and we save each one of these models as a separate time series. For the purpose of our study, we redefine "symptomatology" as any naturally occurring dynamical development of psychological constructs.

Stage 2: Binning data and removing time points

Now, we aim to systematically reduce the quality of the data. We bin a range of the width of the data into n intervals of equal length, where n stands for the number of bins. We also vary the minimum (min) and maximum (max) value of this range to simulate ceiling and floor-effects. Moreover, we remove time points from the data by keeping every k^{th} observation of the simulated data. We systematically decrease the value of n and min and increase the value of k and max, storing any combination of these values.

Stage 3: Data analysis

We will judge the sensitivity of the data by calculating summary statistics and recurrence indicators (recurrence rate, determinism, Shannen entropy,) for each time series in each state of degradation. We judge the sensitivity of the data to degredation by looking at the change in values for each of the indicators, where the full dataset is used as the baseline. We will then map the .

References

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