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Time-varying continuous-time models: Extending the framework for dynamic parameters that change over time

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Abstract

Continuous-time (CT) modeling has become a widely used approach for analyzing longitudinal psychological data, particularly in ecological momentary assessment (EMA) studies. Traditional CT models assume stationarity—i.e., stable process means and (co)variances over time—which may not adequately capture real-world psychological dynamics. Nonstationarity, which can appear due to time-varying auto- and cross-effects, is often expected in psychological processes but remains underexplored in CT modeling.

In this study, we extend an established CT modeling framework for dynamic parameters that change over time, enabling the analysis of nonstationary processes. We implemented this model in Stan and conducted a proof-of-concept simulation study, demonstrating satisfactory parameter recovery under a very limited set of conditions. An empirical illustration using EMA data on depression and loneliness further highlights the practical applicability of the approach.

While this work provides an initial methodological contribution, further refinement is required, particularly in estimation stability, model complexity, and usability. Future research should explore extensions such as measurement error models, individual differences in dynamic change, and nonlinear time dependencies. This study advances the methodological toolbox for studying psychological processes in their full temporal complexity.

Keywords

continuous-time modeling, nonstationarity

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