Pascal R. Deboeck
Research

Notable Summer 2016 — Spring 2021

Five years ago I moved from the University of Kansas to the University of Utah, a move that both enabled and required a substantial shift in my research. After moving to the University of Utah, my initial years were focused on developing local collaborations through participation on grant applications. This goal was supported by the interdisciplinary nature of Psychology at the University of Utah, as well as my role with the Consortium for Families and Health Research. These last five years I have been a part of 22 grants submissions/resubmissions with at least 2 more planned this spring. Of these, three of the grants are presently active: 1) Clinical markers of neonatal opioid withdrawal syndrome: onset, severity, and longitudinal neurodevelopmental outcome (PIs: Barry Lester, Elizabeth Conradt), 2) Family-focused melanoma preventive intervention for children of survivors (PI: Yelena Wu), and 3) Predicting binge and purge episodes from passive and active Apple Watch data using a dynamical systems approach (PIs: Cynthia Bulik, Jonathan Butner). These three grants represent a combined funding of $4.5 million. Between 2021 and 2024 these grants will pay for about 10.8 months of my time.

Other:

— A sole author publication in *Multivariate Behavioral Research* and a first author publication in *Structural Equation Modeling*, which are considered highly aspirational journals among quantitative psychologists

— Completion of a Co-PI grant (*Separating transient and enduring forms of change in adult attachment styles*; R. Chris Fraley, Omri Gillath, Pascal R. Deboeck), with an initial publication in the *Journal of Personality and Social Psychology.*

— Dr. Richard Lerner, a well recognized professor in human development, sought me out due to my expertise in intraindividual modeling to be an advisor for the SoLD Measures and Methods Across the Development Continuum. While presently in its initial phases, this has the potential to be a substantial long-term project focused on fundamentally changing K-12 education through the consideration of individual trajectories of learning and development.

Program of Research

I specialize in the development and application of methods for the analysis of repeated, intensive observations (i.e., intraindividual time series). The increasing availability of diary data, ecological momentary assessments, and other intensive within–person data present a unique opportunity for substantive researchers to explore the dynamic interplay of constructs rather than the static snapshots offered by cross–sectional data. These data present a substantial analytic challenge, due to the complex and nonlinear ways people change; these challenges are amplified in the social, behavioral, and medical sciences due to data characteristics such as sampling rates that are low relative to the rate at which constructs change, large proportions of both measurement and dynamic/process error, and unequally spaced or missing observations. My research is focused on characterizing and modeling the variability observed in intraindividual time series so as to understand how, why and when change occurs on constructs that exhibit frequent, nonlinear, back–and-forth change.

My research integrates methods and ideas from multiple fields. In the physical sciences there is a rich history of describing changing systems (dynamical systems theory) through differential equation modeling; that is, models with elements expressing the change in one construct with respect to another construct. Much of that literature is focused on contexts where tens–of–thousands of observations can be collected under controlled conditions and with relatively little measurement error. The field of statistics is adept at the analysis of cross–sectional data, and linear (or simple nonlinear) change processes, but is often less adept at describing complex nonlinear change. Within the social sciences some areas have experience modeling repeated measurements through methods such as time series analysis, but these methods are often a poor match to the rich substantive theories present in areas such as psychology. The needs for analyzing repeated, within–person self–reports (e.g., affect, quality of life, motivation) requires the combination of these domains. My research integrates dynamical systems theory, a wide range of statistical methods (e.g., structural equation modeling, multilevel modeling, computational/nonparametric, Bayesian statistics), knowledge of existing methods for analyzing repeated observations, and rich substantive theories about intraindividual variability using differential equation modeling. Differential equation modeling presents the potential of representing intricate change across time using few, meaningful parameters; linear models of non-linear trajectories; the ability to model individuals with vastly differing trajectories using a single model; no requirement to align all individuals on an equivalent time scale; and the advantages of parameter estimation associated with continuous versus discrete modeling techniques.

My long–term goals are to transform research in the social, behavioral, and medical sciences so as to increasingly focus on the individual, rather than the "average" person. The collection of intensive, repeated, momentary intraindividual assessments has the potential to allow for personalized, real-time therapy and interventions — if proper analytic tools can be developed and made accessible. Mathematics ensures that personalized analyses are not a quixotic pursuit, as unless all people develop in the same way and change according to the same dynamical rules, inferences based on cross–sectional data will not yield the same inferences as those drawn from studying individuals. The ability to offer truly personalized individual resources therefore hangs on intraindividual methodology, and it is my goal to serve an important role in development and dissemination of these methods.

The following sections present an overview of two components of my quantitative work (*Modeling of Intensive Intraindividual Data*, *Integration of Stochastic Differential Equations*), and substantive work (*Substantive Modeling of Repeated Intraindividual Data*), which symbiotically serve to produce contributions to each other.

Modeling of Intensive Intraindividual Data

Much of my quantitative work is focused on developments for the application of differential equation modeling, with particular attention to the types of data that are common for studies involving within person self–reports, and other measures which cannot achieve observations of particularly high density or precision. One part of this research has focused on advancing methods based on time-delay embedding, for example the estimation of derivatives (how people are changing) over short periods of time. Examples of contributions to the estimation of derivatives include 1) Generalized Local Linear Approximation, which generalized an existing methodology for estimating derivatives to allow for use of additional observations and additional orders of derivatives,[1] 2) Generalized Orthogonal Derivative Estimates, which used a perspective from ANOVA on the decomposition of variance to partition time series variance thus solving a problem with correlated errors that occurs with GLLA,[2] and 3) Empirical Bayes Estimates, which leverages posterior estimates of derivatives to produce more efficient derivative estimates and allows for better estimation with missing data.[3]

I have also worked to promote innovative ideas for substantive research through methodological contributions. Following years of experience working with stress and affect data, Dr. C. S. Bergeman and I proposed a new model for describing a person's ability to dissipate everyday stressors (the reservoir model); existing models were unable to account for the characteristics observed in the data from multiple studies and consequently expansion of the existing available models was necessary.[4] I have also been the lead author on a paper examining the practice of calculating the variance of a time series (e.g., standard deviation, coefficient of variation); this paper conveys the idea that measures such as variance may not match the intuitions expected by many researchers, as these measures do not account for the ordering of observations over time. By accounting for the change of a construct with respect to time (i.e., by calculating derivatives) it may be possible to form statistics that better match researcher expectations (derivative variability analysis).[5] I have also written multiple chapters and a few articles aimed at teaching methods for the fitting of differential equations. One such article introduces derivatives in terms of points (level), straight lines (velocity), and curved lines (acceleration), in an effort to make this language framework more accessible to a wider audience; I believe such common language between substantive and quantitative researchers could lead to a closer correspondence between theory and method.[6]

Integration of Stochastic Differential Equation Models

My work on the application of differential equations has led me to also develop a focus not only on time-delay embedding, but also methods based on the integration of stochastic differential equations. Typically, when few observations are measured across time (e.g., 2-4 observations), methods like the Cross-Lagged Panel Model are used under the assumption that it is impossible to estimate sufficient change scores for the methods described in the prior section. An alternative approach, however, involves the specification of differential equations with stochastic error processes that are then integrated. While many statistical methods produce estimates of effects that are dependent on the interval between observations, these models can produce inferences that are independent of the specific interval between observations selected by the researcher. These approaches also have the potential to examine very different change processes, even with limited observations across time.

My most recent contribution focuses on the implications of dynamical systems theory on clinical interventions, and how the application of stochastic differential equations can potentially guide the selection of interventions that are less likely to produce transient effects.[7] My earlier work on these models related one stochastic differential equation model to a model commonly used for longitudinal mediation,[8] and further considerations of how mediation differs from discrete and continuous time perspectives.[9] I have also provided a new approach for making the fitting of continuous time models more appropriate and accessible to the social sciences.[10] Like the work in the prior section, I aim to share these models with diverse audiences; for example, I have written a chapter about these models for nursing research.[11]

Substantive Modeling of Repeated Intraindividual Data

My quantitative work would not be complete without the challenges and insights from applying longitudinal methodologies to substantive data. I have worked to promote the application of these methods through a variety of substantive collaborations. Often this thinking leads me to consider questions about the role of variability across a variety of domains. While most researchers have become adept at asking questions about the mean difference(s) between groups, or with the change in some predictor, questions about variance and variability are often less common but may be at least as important as mean difference questions in many contexts. Collaboration with substantive researchers has informed my thoughts regarding the directions in which intraindividual methodology needs to develop. One of my ongoing goals is to collaborate with researchers across a diverse set of domains. The most interesting applications given my quantitative interests are domains where repeated observations (e.g., 4 to 100 observations) can be collected on two or more constructs. A few examples of substantive domains where I have worked on modeling intraindividual change and variability include:

— the interplay of stress and affect and its relation to resiliency and health outcomes in later life (Dr. C. S. Bergeman; Dr. Mignon Montpetit)[12,13]
— changes in adult attachment (Dr. Omri Gillath, Dr. R. Chris Fraley; Dr. Gery Karantzas)[14]
— predicting bing and purge episodes from passive sensor data (Dr. Cynthia M. Bulik, Dr. Jonathan Butner, et al.)[15]
— individual trajectories of learning and development in K-12 students using intensive intraindividual data (Dr. Richard Lerner, et al.)
— ambulatory blood pressure monitoring and cognitive decline (Dr. David Johnson)
— using momentary derivative estimates to gauge driver attention (Dr. Paul Atchley)[16]
— maternal depression symptomatology and child behavior (Dr. Jody Nicholson)[17]
— human movement in dance and conversation (Dr. Steven M. Boker)[18]

Footnotes

[1]Boker, S. M., *Deboeck, P. R.*, Edler, C. & Keel, P. K. (2009). Generalized Local Linear Approximation of Derivatives from Time Series. In S. Chow, E. Ferrer & F. Hsieh (Eds.), Statistical Methods for Modeling Human Dynamics: An Interdisciplinary Dialogue, pp. 161–178. New York, NY: Taylor & Francis Group.

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[3]*Deboeck, P. R.* (2020). Empirical Bayes Derivative Estimates. Multivariate Behavioral Research, 55(3), 382–404.

[4]*Deboeck, P. R.* & Bergeman, C. S. (2013). The Reservoir Model: A Differential Equation Model of Psychological Capacity. Psychological Methods, 18(2), 237–256.

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[11]*Deboeck, P. R.* & Boker, S. M. (2015). Analysis of Dynamic Systems: The Modeling of Change and Variability. In S. J. Henly (Ed.) Routledge International Handbook of Advanced Quantitative Methods in Nursing Research, pp. 170–186. Abingdon,UK: Routledge/Taylor & Francis.

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[13]Montpetit, M. A., Bergeman, C. S., *Deboeck, P. R.*, Tiberio, S. S. & Boker, S. M. (2010) Resilience–As–Process: Negative Affect, Stress, and Coupled Dynamical Systems. Psychology and Aging, 25 (3), 631–640.

[14]Fraley, R. C., Gillath, O., & *Deboeck, P. R.* (2020). Do life events lead to enduring changes in adult at- tachment styles? A naturalistic longitudinal investigation. Journal of Personality and Social Psychology.

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