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References

Aalen et al.: Can we believe the DAGs? A comment on the relationship between causal DAGs and mechanisms **Aalen-Roysland-Gran-etal-2016**

Odd O. Aalen, Kjetil Røysland, Jon Michael Gran, Roger Kouyos, et al. "Can we believe the DAGs? A comment on the relationship between causal DAGs and mechanisms". In: *Statistical Methods in Medical Research* 25.5 (July 2016), pp. 2294–2314. ISSN: 1477-0334. DOI: 10.1177/0962280213520436.

Abstract: Directed acyclic graphs (DAGs) play a large role in the modern approach to causal inference. DAGs describe the relationship between measurements taken at various discrete times including the effect of interventions. The causal mechanisms, on the other hand, would naturally be assumed to be a continuous process operating over time in a cause–effect fashion. How does such immediate causation, that is causation occurring over very short time intervals, relate to DAGs constructed from discrete observations? We introduce a time-continuous model and simulate discrete observations in order to judge the relationship between the DAG and the immediate causal model. We find that there is no clear relationship; indeed the Bayesian network described by the DAG may not relate to the causal model. Typically, discrete observations of a process will obscure the conditional dependencies that are represented in the underlying mechanistic model of the process. It is therefore doubtful whether DAGs are always suited to describe causal relationships unless time is explicitly considered in the model. We relate the issues to mechanistic modeling by using the concept of local (in)dependence. An example using data from the Swiss HIV Cohort Study is presented.

Aalen et al.: Causality, mediation and time: A dynamic viewpoint

Aalen-Roysland-Gran-etal-2012

Odd O. Aalen, Kjetil Røysland, Jon Michael Gran, and Bruno Ledergerber. "Causality, mediation and time: A dynamic viewpoint". In: *Journal of the Royal Statistical Society. Series A (Statistics in Society)* 175.4 (2012), pp. 831–861. ISSN: 09641998, 1467985X. URL: http://www.jstor.org/stable/23355305.

Abstract: Time dynamics are often ignored in causal modelling. Clearly, causality must operate in time and we show how this corresponds to a mechanistic, or system, understanding of causality. The established counterfactual definitions of direct and indirect effects depend on an ability to manipulate the mediator which may not hold in practice, and we argue that a mechanistic view may be better. Graphical representations based on local independence graphs and dynamic path analysis are used to facilitate communication as well as providing an overview of the dynamic relations 'at a glance'. The relationship between causality as understood in a mechanistic and in an interventionist sense is discussed. An example using data from the Swiss HIV Cohort Study is presented.

Asparouhov et al.: Dynamic structural equation models

Asparouhov-Hamaker-Muthen-2017

Tihomir Asparouhov, Ellen L. Hamaker, and Bengt Muthén. "Dynamic structural equation models". In: *Structural Equation Modeling: A Multidisciplinary Journal* 25.3 (Dec. 2017), pp. 359–388. DOI: 10.1080/10705511.2017.1406803.

Abstract: This article presents dynamic structural equation modeling (DSEM), which can be used to study the evolution of observed and latent variables as well as the structural equation models over time. DSEM is suitable for analyzing intensive longitudinal data where observations from multiple individuals are collected at many points in time. The modeling framework encompasses previously

published DSEM models and is a comprehensive attempt to combine time-series modeling with structural equation modeling. DSEM is estimated with Bayesian methods using the Markov chain Monte Carlo Gibbs sampler and the Metropolis-Hastings sampler. We provide a detailed description of the estimation algorithm as implemented in the Mplus software package. DSEM can be used for longitudinal analysis of any duration and with any number of observations across time. Simulation studies are used to illustrate the framework and study the performance of the estimation method. Methods for evaluating model fit are also discussed.

Biesanz et al.: Assessing mediational models: Testing and interval estimation for indirect effects **Biesanz-Falk-Savalei-2010**

Jeremy C. Biesanz, Carl F. Falk, and Victoria Savalei. "Assessing mediational models: Testing and interval estimation for indirect effects". In: *Multivariate Behavioral Research* 45.4 (Aug. 2010), pp. 661–701. DOI: 10.1080/00273171.2010.498292.

Abstract: Theoretical models specifying indirect or mediated effects are common in the social sciences. An indirect effect exists when an independent variable's influence on the dependent variable is mediated through an intervening variable. Classic approaches to assessing such mediational hypotheses (Baron & Kenny, 1986; Sobel, 1982) have in recent years been supplemented by computationally intensive methods such as bootstrapping, the distribution of the product methods, and hierarchical Bayesian Markov chain Monte Carlo (MCMC) methods. These different approaches for assessing mediation are illustrated using data from Dunn, Biesanz, Human, and Finn (2007). However, little is known about how these methods perform relative to each other, particularly in more challenging situations, such as with data that are incomplete and/or nonnormal. This article presents an extensive Monte Carlo simulation evaluating a host of approaches for assessing mediation. We examine Type I error rates, power, and coverage. We study normal and nonnormal data as well as complete and incomplete data. In addition, we adapt a method, recently proposed in statistical literature, that does not rely on confidence intervals (CIs) to test the null hypothesis of no indirect effect. The results suggest that the new inferential method–the partial posterior p

value–slightly outperforms existing ones in terms of maintaining Type I error rates while maximizing power, especially with incomplete data. Among confidence interval approaches, the bias-corrected accelerated (BCa) bootstrapping approach often has inflated Type I error rates and inconsistent coverage and is not recommended. In contrast, the bootstrapped percentile confidence interval and the hierarchical Bayesian MCMC method perform best overall, maintaining Type I error rates, exhibiting reasonable power, and producing stable and accurate coverage rates.

Blanca et al.: Skewness and kurtosis in real data samples

Blanca-Arnau-LopezMontiel-etal-2013

Maria J. Blanca et al. "Skewness and kurtosis in real data samples". In: *Methodology* 9.2 (May 2013), pp. 78–84. DOI: 10.1027/1614-2241/a000057.

Abstract: Parametric statistics are based on the assumption of normality. Recent findings suggest that Type I error and power can be adversely affected when data are non-normal. This paper aims to assess the distributional shape of real data by examining the values of the third and fourth central moments as a measurement of skewness and kurtosis in small samples. The analysis concerned 693 distributions with a sample size ranging from 10 to 30. Measures of cognitive ability and of other psychological variables were included. The results showed that skewness ranged between -2.49 and 2.33. The values of kurtosis ranged between -1.92 and 7.41. Considering skewness and kurtosis together the results indicated that only 5.5% of distributions were close to expected values under normality. Although extreme contamination does not seem to be very frequent, the findings are consistent with previous research suggesting that normality is not the rule with real data.

Boettiger et al.: An introduction to Rocker: Docker containers for R

Boettiger-Eddelbuettel-2017

Carl Boettiger and Dirk Eddelbuettel. "An introduction to Rocker: Docker containers for R". In: *The R Journal* 9.2 (2017), p. 527. DOI: 10.32614/rj-2017-065.

Abstract: We describe the Rocker project, which provides a widely-used suite of Docker images with customized R environments for particular tasks. We discuss how this suite is organized, and how these tools can increase portability, scaling, reproducibility, and convenience of R users and developers.

Chen et al.: Vector autoregression, structural equation modeling, and their synthesis in neuroimaging data analysis **Chen-Daniel-Ziad-etal-2011**

Gang Chen et al. "Vector autoregression, structural equation modeling, and their synthesis in neuroimaging data analysis". In: *Computers in Biology and Medicine* 41.12 (Dec. 2011), pp. 1142–1155. DOI: 10.1016/j.compbiomed.2011.09.004.

Abstract: Vector autoregression (VAR) and structural equation modeling (SEM) are two popular brain-network modeling tools. VAR, which is a data-driven approach, assumes that connected regions exert time-lagged influences on one another. In contrast, the hypothesis-driven SEM is used to validate an existing connectivity model where connected regions have contemporaneous interactions among them. We present the two models in detail and discuss their applicability to FMRI data, and their interpretational limits. We also propose a unified approach that models both lagged and contemporaneous effects. The unifying model, structural vector autoregression (SVAR), may improve statistical and explanatory power, and avoid some prevalent pitfalls that can occur when VAR and SEM are utilized separately.

Chow et al.: Equivalence and differences between structural equation modeling and state-space modeling techniques **Chow-Ho-Hamaker-etal-2010**

Sy-Miin Chow et al. "Equivalence and differences between structural equation modeling and state-space modeling techniques". In: *Structural Equation Modeling: A Multidisciplinary Journal* 17.2 (Apr. 2010), pp. 303–332. DOI: 10.1080/10705511003661553.

Abstract: State-space modeling techniques have been compared to structural equation modeling (SEM) techniques in various contexts but their unique strengths have often been overshadowed by their similarities to SEM. In this article, we provide a comprehensive discussion of these 2 approaches' similarities and differences through analytic comparisons and numerical simulations, with a focus on their use in representing intraindividual dynamics and interindividual differences. To demonstrate the respective strengths and weaknesses of the 2 approaches in representing these 2 aspects, we simulated data under (a) a cross-sectional common factor model, (b) a latent difference score model with random effects in intercept and slope, and (c) a bivariate dynamic factor analysis model with auto- and cross-regression parameters. Possible ways in which SEM and state-space modeling can be utilized as complementary tools in representing human developmental and other related processes are discussed.

Curran et al.: The disaggregation of within-person and between-person effects in longitudinal models of change **Curran-Bauer-2011**

Patrick J. Curran and Daniel J. Bauer. "The disaggregation of within-person and between-person effects in longitudinal models of change". In: *Annual Review of Psychology* 62.1 (Jan. 2011), pp. 583–619. DOI: 10.1146/annurev.psych.093008.100356.

Abstract: Longitudinal models are becoming increasingly prevalent in the behavioral sciences, with key advantages including increased power, more comprehensive measurement, and establishment of temporal precedence. One particularly salient strength offered by longitudinal data is the ability to disaggregate between-person and within-person effects in the regression of an outcome on a time-varying covariate. However, the ability to disaggregate these effects has not been fully capitalized upon in many social science research applications. Two likely reasons for this omission are the general lack of discussion of disaggregating effects in the substantive literature and the need to overcome several remaining analytic challenges that limit existing quantitative methods used to isolate these effects in practice. This review explores both substantive and quantitative issues related to the disaggregation of effects over time, with a particular emphasis placed on the multilevel

model. Existing analytic methods are reviewed, a general approach to the problem is proposed, and both the existing and proposed methods are demonstrated using several artificial data sets. Potential limitations and directions for future research are discussed, and recommendations for the disaggregation of effects in practice are offered.

de Haan-Rietdijk et al.: Discrete- vs. continuous-time modeling of unequally spaced experience sampling method data HaanRietdijk-Voelkle-Keijsers-Hamaker-2017

Silvia de Haan-Rietdijk et al. "Discrete- vs. continuous-time modeling of unequally spaced experience sampling method data". In: *Frontiers in Psychology* 8 (Oct. 2017). ISSN: 1664-1078. DOI: 10.3389/fpsyg.2017.01849.

Abstract: The Experience Sampling Method is a common approach in psychological research for collecting intensive longitudinal data with high ecological validity. One characteristic of ESM data is that it is often unequally spaced, because the measurement intervals within a day are deliberately varied, and measurement continues over several days. This poses a problem for discrete-time (DT) modeling approaches, which are based on the assumption that all measurements are equally spaced. Nevertheless, DT approaches such as (vector) autoregressive modeling are often used to analyze ESM data, for instance in the context of affective dynamics research. There are equivalent continuous-time (CT) models, but they are more difficult to implement. In this paper we take a pragmatic approach and evaluate the practical relevance of the violated model assumption in DT AR(1) and VAR(1) models, for the N = 1 case. We use simulated data under an ESM measurement design to investigate the bias in the parameters of interest under four different model implementations, ranging from the true CT model that accounts for all the exact measurement times, to the crudest possible DT model implementation, where even the nighttime is treated as a regular interval. An analysis of empirical affect data illustrates how the differences between DT and CT modeling can play out in practice. We find that the size and the direction of the bias in DT (V)AR models for unequally spaced ESM data depend quite strongly on the true parameter in addition to

data characteristics. Our recommendation is to use CT modeling whenever possible, especially now that new software implementations have become available.

Deboeck et al.: Integration of stochastic differential equations using structural equation modeling: A method to facilitate model fitting and pedagogy Deboeck-Boulton-2016

Pascal R. Deboeck and Aaron J. Boulton. "Integration of stochastic differential equations using structural equation modeling: A method to facilitate model fitting and pedagogy". In: *Structural Equation Modeling: A Multidisciplinary Journal* 23.6 (Oct. 2016), pp. 888–903. ISSN: 1532-8007. DOI: 10.1080/10705511.2016.1218763.

Abstract: Stochastic differential equation (SDE) models are a promising method for modeling intraindividual change and variability. Applications of SDEs in the social sciences are relatively limited, as these models present conceptual and programming challenges. This article presents a novel method for conceptualizing SDEs. This method uses structural equation modeling (SEM) conventions to simplify SDE specification, the flexibility of SEM to expand the range of SDEs that can be fit, and SEM diagram conventions to facilitate the teaching of SDE concepts. This method is a variation of latent difference scores (McArdle, 2009; McArdle & Hamagami, 2001) and the oversampling approach (Singer, 2012), and approximates the advantages of analytic methods such as the exact discrete model (Oud & Jansen, 2000) while retaining the modeling fiexibility of methods such as latent differential equation modeling (Boker, Neale, & Rausch, 2004). A simulation and empirical example are presented to illustrate that this method can be implemented on current computing hardware, produces good approximations of analytic solutions, and can flexibly accommodate novel models.

Deboeck et al.: No need to be discrete: A method for continuous time mediation analysis Deboeck-Preacher-2015

Pascal R. Deboeck and Kristopher J. Preacher. "No need to be discrete: A method for continuous

time mediation analysis". In: *Structural Equation Modeling: A Multidisciplinary Journal* 23.1 (June 2015), pp. 61–75. DOI: 10.1080/10705511.2014.973960.

Abstract: Mediation is one concept that has shaped numerous theories. The list of problems associated with mediation models, however, has been growing. Mediation models based on cross-sectional data can produce unexpected estimates, so much so that making longitudinal or causal inferences is inadvisable. Even longitudinal mediation models have faults, as parameter estimates produced by these models are specific to the lag between observations, leading to much debate over appropriate lag selection. Using continuous time models (CTMs) rather than commonly employed discrete time models, one can estimate lag-independent parameters. We demonstrate methodology that allows for continuous time mediation analyses, with attention to concepts such as indirect and direct effects, partial mediation, the effect of lag, and the lags at which relations become maximal. A simulation compares common longitudinal mediation methods with CTMs. Reanalysis of a published covariance matrix demonstrates that CTMs can be fit to data used in longitudinal mediation studies.

Demeshko et al.: A novel continuous and structural VAR modeling approach and its application to reactor noise analysis **Demeshko-Washio-Kawahara-etal-2015**

Marina Demeshko et al. "A novel continuous and structural VAR modeling approach and its application to reactor noise analysis". In: *ACM Transactions on Intelligent Systems and Technology* 7.2 (Nov. 2015), pp. 1–22. DOI: 10.1145/2710025.

Abstract: A vector autoregressive model in discrete time domain (DVAR) is often used to analyze continuous time, multivariate, linear Markov systems through their observed time series data sampled at discrete timesteps. Based on previous studies, the DVAR model is supposed to be a non-canonical representation of the system, that is, it does not correspond to a unique system bijectively. However, in this article, we characterize the relations of the DVAR model with its corresponding Structural Vector AR (SVAR) and Continuous Time Vector AR (CTVAR) models through a finite difference method across continuous and discrete time domain. We further clarify that the DVAR

model of a continuous time, multivariate, linear Markov system is canonical under a highly generic condition. Our analysis shows that we can uniquely reproduce its SVAR and CTVAR models from the DVAR model. Based on these results, we propose a novel Continuous and Structural Vector Autoregressive (CSVAR) modeling approach to derive the SVAR and the CTVAR models from their DVAR model empirically derived from the observed time series of continuous time linear Markov systems. We demonstrate its superior performance through some numerical experiments on both artificial and real-world data.

Driver et al.: Continuous time structural equation modeling with R package ctsem

Driver-Oud-Voelkle-2017

Charles C. Driver, Johan H. L. Oud, and Manuel C. Voelkle. "Continuous time structural equation modeling with R package ctsem". In: *Journal of Statistical Software* 77.5 (2017). ISSN: 1548-7660. DOI: 10.18637/jss.v077.i05.

Abstract: We introduce ctsem, an R package for continuous time structural equation modeling of panel (N ¿ 1) and time series (N = 1) data, using full information maximum likelihood. Most dynamic models (e.g., cross-lagged panel models) in the social and behavioural sciences are discrete time models. An assumption of discrete time models is that time intervals between measurements are equal, and that all subjects were assessed at the same intervals. Violations of this assumption are often ignored due to the difficulty of accounting for varying time intervals, therefore parameter estimates can be biased and the time course of effects becomes ambiguous. By using stochastic differential equations to estimate an underlying continuous process, continuous time models allow for any pattern of measurement occasions. By interfacing to OpenMx, ctsem combines the flexible specification of structural equation models with the enhanced data gathering opportunities and improved estimation of continuous time models. ctsem can estimate relationships over time for multiple latent processes, measured by multiple noisy indicators with varying time intervals between observations. Within and between effects are estimated simultaneously by modeling both observed covariates and unobserved heterogeneity. Exogenous shocks with different shapes, group differences,

higher order diffusion effects and oscillating processes can all be simply modeled. We first introduce and define continuous time models, then show how to specify and estimate a range of continuous time models using ctsem.

Driver et al.: Hierarchical Bayesian continuous time dynamic modeling.

Driver-Voelkle-2018

Charles C. Driver and Manuel C. Voelkle. "Hierarchical Bayesian continuous time dynamic modeling." In: *Psychological Methods* 23.4 (Dec. 2018), pp. 774–799. ISSN: 1082-989X. DOI: 10.1037/met0000168.

Abstract: Continuous time dynamic models are similar to popular discrete time models such as autoregressive cross-lagged models, but through use of stochastic differential equations can accurately account for differences in time intervals between measurements, and more parsimoniously specify complex dynamics. As such they offer powerful and flexible approaches to understand ongoing psychological processes and interventions, and allow for measurements to be taken a variable number of times, and at irregular intervals. However, limited developments have taken place regarding the use of continuous time models in a fully hierarchical context, in which all model parameters are allowed to vary over individuals. This has meant that questions regarding individual differences in parameters have had to rely on single-subject time series approaches, which require far more measurement occasions per individual. We present a hierarchical Bayesian approach to estimating continuous time dynamic models, allowing for individual variation in all model parameters. We also describe an extension to the ctsem package for R, which interfaces to the Stan software and allows simple specification and fitting of such models. To demonstrate the approach, we use a subsample from the German socioeconomic panel and relate overall life satisfaction and satisfaction with health.

Dudgeon: Some improvements in confidence intervals for standardized regression coefficients **Dudgeon-2017**

Paul Dudgeon. "Some improvements in confidence intervals for standardized regression coefficients". In: *Psychometrika* 82.4 (Mar. 2017), pp. 928–951. DOI: 10.1007/s11336-017-9563-z.

Abstract: Yuan and Chan (Psychometrika 76:670-690, 2011. doi:10.1007/S11336-011-9224-6) derived consistent confidence intervals for standardized regression coefficients under fixed and random score assumptions. Jones and Waller (Psychometrika 80:365-378, 2015. doi:10.1007/S11336-013-9380-Y) extended these developments to circumstances where data are non-normal by examining confidence intervals based on Browne's (Br J Math Stat Psychol 37:62-83, 1984. doi:10.1111/j.2044-8317.1984.tb00789.x) asymptotic distribution-free (ADF) theory. Seven different heteroscedastic-consistent (HC) estimators were investigated in the current study as potentially better solutions for constructing confidence intervals on standardized regression coefficients under non-normality. Normal theory, ADF, and HC estimators were evaluated in a Monte Carlo simulation. Findings confirmed the superiority of the HC3 (MacKinnon and White, J Econ 35:305-325, 1985. doi:10.1016/0304-4076(85)90158-7) and HC5 (Cribari-Neto and Da Silva, Adv Stat Anal 95:129-146, 2011. doi:10.1007/s10182-010-0141-2) interval estimators over Jones and Waller's ADF estimator under all conditions investigated, as well as over the normal theory method. The HC5 estimator was more robust in a restricted set of conditions over the HC3 estimator. Some possible extensions of HC estimators to other effect size measures are considered for future developments.

Eddelbuettel et al.: Extending R with C++: A brief introduction to Rcpp **Eddelbuettel-Balamuta-2017**

Dirk Eddelbuettel and James Joseph Balamuta. "Extending R with C++: A brief introduction to Rcpp". In: *PeerJ Preprints* 3188v1.3 (Aug. 2017). DOI: 10.7287/peerj.preprints.3188v1.

Abstract: R has always provided an application programming interface (API) for extensions. Based on the C language, it uses a number of macros and other low-level constructs to exchange data

structures between the R process and any dynamically-loaded component modules authors added to it. With the introduction of the Rcpp package, and its later refinements, this process has become considerably easier yet also more robust. By now, Rcpp has become the most popular extension mechanism for R. This article introduces Rcpp, and illustrates with several examples how the Rcpp Attributes mechanism in particular eases the transition of objects between R and C++ code.

Eddelbuettel et al.: Rcpp: Seamless R and C++ integration **Eddelbuettel-Francois-2011**

Dirk Eddelbuettel and Romain François. "Rcpp: Seamless R and C++ integration". In: *Journal of Statistical Software* 40.8 (2011). DOI: 10.18637/jss.v040.i08.

Abstract: The Rcpp package simplifies integrating C++ code with R. It provides a consistent C++ class hierarchy that maps various types of R objects (vectors, matrices, functions, environments, ...) to dedicated C++ classes. Object interchange between R and C++ is managed by simple, flexible and extensible concepts which include broad support for C++ Standard Template Library idioms. C++ code can both be compiled, linked and loaded on the fly, or added via packages. Flexible error and exception code handling is provided. Rcpp substantially lowers the barrier for programmers wanting to combine C++ code with R.

Eddelbuettel et al.: RcppArmadillo: Accelerating R with high-performance C++ linear algebra **Eddelbuettel-Sanderson-2014**

Dirk Eddelbuettel and Conrad Sanderson. "RcppArmadillo: Accelerating R with high-performance C++ linear algebra". In: *Computational Statistics & Data Analysis* 71 (Mar. 2014), pp. 1054–1063. DOI: 10.1016/j.csda.2013.02.005.

Abstract: The R statistical environment and language has demonstrated particular strengths for interactive development of statistical algorithms, as well as data modelling and visualisation. Its current implementation has an interpreter at its core which may result in a performance penalty in

comparison to directly executing user algorithms in the native machine code of the host CPU. In contrast, the C++ language has no built-in visualisation capabilities, handling of linear algebra or even basic statistical algorithms; however, user programs are converted to high-performance machine code, ahead of execution. A new method avoids possible speed penalties in R by using the Rcpp extension package in conjunction with the Armadillo C++ matrix library. In addition to the inherent performance advantages of compiled code, Armadillo provides an easy-to-use template-based meta-programming framework, allowing the automatic pooling of several linear algebra operations into one, which in turn can lead to further speedups. With the aid of Rcpp and Armadillo, conversion of linear algebra centred algorithms from R to C++ becomes straightforward. The algorithms retain the overall structure as well as readability, all while maintaining a bidirectional link with the host R environment. Empirical timing comparisons of R and C++ implementations of a Kalman filtering algorithm indicate a speedup of several orders of magnitude.

Efron: Bayesian inference and the parametric bootstrap **Efron-2012**

Bradley Efron. "Bayesian inference and the parametric bootstrap". In: *The Annals of Applied Statistics* 6.4 (Dec. 2012). DOI: 10.1214/12-aoas571.

Abstract: The parametric bootstrap can be used for the efficient computation of Bayes posterior distributions. Importance sampling formulas take on an easy form relating to the deviance in exponential families and are particularly simple starting from Jeffreys invariant prior. Because of the i.i.d. nature of bootstrap sampling, familiar formulas describe the computational accuracy of the Bayes estimates. Besides computational methods, the theory provides a connection between Bayesian and frequentist analysis. Efficient algorithms for the frequentist accuracy of Bayesian inferences are developed and demonstrated in a model selection example.

Enders et al.: A Bayesian approach for estimating mediation effects with missing data

Enders-Fairchild-MacKinnon-2013

Craig K. Enders, Amanda J. Fairchild, and David P. MacKinnon. "A Bayesian approach for estimating mediation effects with missing data". In: *Multivariate Behavioral Research* 48.3 (May 2013), pp. 340–369. ISSN: 1532-7906. DOI: 10.1080/00273171.2013.784862.

Abstract: Methodologists have developed mediation analysis techniques for a broad range of substantive applications, yet methods for estimating mediating mechanisms with missing data have been understudied. This study outlined a general Bayesian missing data handling approach that can accommodate mediation analyses with any number of manifest variables. Computer simulation studies showed that the Bayesian approach produced frequentist coverage rates and power estimates that were comparable to those of maximum likelihood with the bias-corrected bootstrap. We share a SAS macro that implements Bayesian estimation and use two data analysis examples to demonstrate its use.

Epskamp et al.: Estimating psychological networks and their accuracy: A tutorial paper

Epskamp-Borsboom-Fried-2017

Sacha Epskamp, Denny Borsboom, and Eiko I. Fried. "Estimating psychological networks and their accuracy: A tutorial paper". In: *Behavior Research Methods* 50.1 (Mar. 2017), pp. 195–212. ISSN: 1554-3528. DOI: 10.3758/s13428-017-0862-1.

Abstract: The usage of psychological networks that conceptualize behavior as a complex interplay of psychological and other components has gained increasing popularity in various research fields. While prior publications have tackled the topics of estimating and interpreting such networks, little work has been conducted to check how accurate (i.e., prone to sampling variation) networks are estimated, and how stable (i.e., interpretation remains similar with less observations) inferences from the network structure (such as centrality indices) are. In this tutorial paper, we aim to introduce the

reader to this field and tackle the problem of accuracy under sampling variation. We first introduce the current state-of-the-art of network estimation. Second, we provide a rationale why researchers should investigate the accuracy of psychological networks. Third, we describe how bootstrap routines can be used to (A) assess the accuracy of estimated network connections, (B) investigate the stability of centrality indices, and (C) test whether network connections and centrality estimates for different variables differ from each other. We introduce two novel statistical methods: for (B) the correlation stability coefficient, and for (C) the bootstrapped difference test for edge-weights and centrality indices. We conducted and present simulation studies to assess the performance of both methods. Finally, we developed the free R-package bootnet that allows for estimating psychological networks in a generalized framework in addition to the proposed bootstrap methods. We showcase bootnet in a tutorial, accompanied by R syntax, in which we analyze a dataset of 359 women with posttraumatic stress disorder available online.

Epskamp et al.: The Gaussian graphical model in cross-sectional and time-series data

Epskamp-Lourens-Mottus-etal-2018

Sacha Epskamp, Lourens J. Waldorp, et al. "The Gaussian graphical model in cross-sectional and time-series data". In: *Multivariate Behavioral Research* 53.4 (Apr. 2018), pp. 453–480. DOI: 10.1080/00273171.2018.1454823.

Abstract: We discuss the Gaussian graphical model (GGM; an undirected network of partial correlation coefficients) and detail its utility as an exploratory data analysis tool. The GGM shows which variables predict one-another, allows for sparse modeling of covariance structures, and may highlight potential causal relationships between observed variables. We describe the utility in three kinds of psychological data sets: data sets in which consecutive cases are assumed independent (e.g., cross-sectional data), temporally ordered data sets (e.g., n = 1 time series), and a mixture of the 2 (e.g., n ¿ 1 time series). In time-series analysis, the GGM can be used to model the residual structure of a vector-autoregression analysis (VAR), also termed graphical VAR. Two network models can then be obtained: a temporal network and a contemporaneous network. When analyzing

data from multiple subjects, a GGM can also be formed on the covariance structure of stationary means-the between-subjects network. We discuss the interpretation of these models and propose estimation methods to obtain these networks, which we implement in the R packages graphicalVAR and mlVAR. The methods are showcased in two empirical examples, and simulation studies on these methods are included in the supplementary materials.

Fairchild et al.: Using mediation and moderation analyses to enhance prevention research **Fairchild-MacKinnon-2014**

Amanda J. Fairchild and David P. MacKinnon. "Using mediation and moderation analyses to enhance prevention research". In: *Defining Prevention Science*. Springer US, 2014, pp. 537–555. DOI: 10.1007/978-1-4899-7424-2_23.

Abstract: Integrating mediating and moderating variables into prevention research can refine interventions and guide program evaluation by demonstrating how and for whom programs work, as well as lending insight into the construct validity of an intervention. In this way, program development and evaluation strategies that incorporate mediation and moderation analyses contribute to our ability to affect behavioral change. This chapter aims to illustrate how mediation and moderation analyses enhance and inform prevention and intervention work. To that end we define and differentiate the models, discuss their application to prevention programming and research, and provide information on their estimation for individuals seeking to implement these analyses.

Fritz et al.: Explanation of two anomalous results in statistical mediation analysis **Fritz-Taylor-MacKinnon-2012**

Matthew S. Fritz, Aaron B. Taylor, and David P. MacKinnon. "Explanation of two anomalous results in statistical mediation analysis". In: *Multivariate Behavioral Research* 47.1 (Feb. 2012), pp. 61–87. DOI: 10.1080/00273171.2012.640596.

Abstract: Previous studies of different methods of testing mediation models have consistently found two anomalous results. The first result is elevated Type I error rates for the bias-corrected and accelerated bias-corrected bootstrap tests not found in nonresampling tests or in resampling tests that did not include a bias correction. This is of special concern as the bias-corrected bootstrap is often recommended and used due to its higher statistical power compared with other tests. The second result is statistical power reaching an asymptote far below 1.0 and in some conditions even declining slightly as the size of the relationship between X and M, a, increased. Two computer simulations were conducted to examine these findings in greater detail. Results from the first simulation found that the increased Type I error rates for the bias-corrected and accelerated bias-corrected bootstrap are a function of an interaction between the size of the individual paths making up the mediated effect and the sample size, such that elevated Type I error rates occur when the sample size is small and the effect size of the nonzero path is medium or larger. Results from the second simulation found that stagnation and decreases in statistical power as a function of the effect size of the a path occurred primarily when the path between M and Y, b, was small. Two empirical mediation examples are provided using data from a steroid prevention and health promotion program aimed at high school football players (Athletes Training and Learning to Avoid Steroids; Goldberg et al., 1996), one to illustrate a possible Type I error for the bias-corrected bootstrap test and a second to illustrate a loss in power related to the size of a. Implications of these findings are discussed.

Gates et al.: Automatic search for fMRI connectivity mapping: An alternative to Granger causality testing using formal equivalences among SEM path modeling, VAR, and unified SEM **Gates-Molenaar-Hillary-etal-2010**

Kathleen M. Gates et al. "Automatic search for fMRI connectivity mapping: An alternative to Granger causality testing using formal equivalences among SEM path modeling, VAR, and unified SEM". In: *NeuroImage* 50.3 (Apr. 2010), pp. 1118–1125. DOI: 10.1016/j.neuroimage.2009.12.117.

Abstract: Modeling the relationships among brain regions of interest (ROIs) carries unique potential to explicate how the brain orchestrates information processing. However, hurdles arise when using functional MRI data. Variation in ROI activity contains sequential dependencies and shared influences on synchronized activation. Consequently, both lagged and contemporaneous relationships must be considered for unbiased statistical parameter estimation. Identifying these relationships using a data-driven approach could guide theory-building regarding integrated processing. The present paper demonstrates how the unified SEM attends to both lagged and contemporaneous influences on ROI activity. Additionally, this paper offers an approach akin to Granger causality testing, Lagrange multiplier testing, for statistically identifying directional influence among ROIs and employs this approach using an automatic search procedure to arrive at the optimal model. Rationale for this equivalence is offered by explicating the formal relationships among path modeling, vector autoregression, and unified SEM. When applied to simulated data, biases in estimates which do not consider both lagged and contemporaneous paths become apparent. Finally, the use of unified SEM with the automatic search procedure is applied to an empirical data example.

Gu et al.: A state space modeling approach to mediation analysis

Gu-Preacher-Ferrer-2014

Fei Gu, Kristopher J. Preacher, and Emilio Ferrer. "A state space modeling approach to mediation analysis". In: *Journal of Educational and Behavioral Statistics* 39.2 (Apr. 2014), pp. 117–143. ISSN: 1935-1054. DOI: 10.3102/1076998614524823.

Abstract: Mediation is a causal process that evolves over time. Thus, a study of mediation requires data collected throughout the process. However, most applications of mediation analysis use cross-sectional rather than longitudinal data. Another implicit assumption commonly made in longitudinal designs for mediation analysis is that the same mediation process universally applies to all members of the population under investigation. This assumption ignores the important issue of ergodicity before aggregating the data across subjects. We first argue that there exists a discrepancy between the concept of mediation and the research designs that are typically used to investigate it.

Second, based on the concept of ergodicity, we argue that a given mediation process probably is not equally valid for all individuals in a population. Therefore, the purpose of this article is to propose a two-faceted solution. The first facet of the solution is that we advocate a single-subject time-series design that aligns data collection with researchers' conceptual understanding of mediation. The second facet is to introduce a flexible statistical method—the state space model—as an ideal technique to analyze single-subject time series data in mediation studies. We provide an overview of the state space method and illustrative applications using both simulated and real time series data. Finally, we discuss additional issues related to research design and modeling.

E. L. Hamaker et al.: Modeling affect dynamics: State of the art and future challenges

Hamaker-Ceulemans-Grasman-etal-2015

E. L. Hamaker et al. "Modeling affect dynamics: State of the art and future challenges". In: *Emotion Review* 7.4 (July 2015), pp. 316–322. ISSN: 1754-0747. DOI: 10.1177/1754073915590619.

Abstract: The current article aims to provide an up-to-date synopsis of available techniques to study affect dynamics using intensive longitudinal data (ILD). We do so by introducing the following eight dichotomies that help elucidate what kind of data one has, what process aspects are of interest, and what research questions are being considered: (1) single- versus multiple-person data; (2) univariate versus multivariate models; (3) stationary versus nonstationary models; (4) linear versus nonlinear models; (5) discrete time versus continuous time models; (6) discrete versus continuous variables; (7) time versus frequency domain; and (8) modeling the process versus computing descriptives. In addition, we discuss what we believe to be the most urging future challenges regarding the modeling of affect dynamics.

Ellen L. Hamaker et al.: A critique of the cross-lagged panel model

Hamaker-Kuiper-Grasman-2015

Ellen L. Hamaker, Rebecca M. Kuiper, and Raoul P. P. P. Grasman. "A critique of the cross-lagged panel model". In: *Psychological Methods* 20.1 (2015), pp. 102–116. DOI: 10.1037/a0038889.

Abstract: The cross-lagged panel model (CLPM) is believed by many to overcome the problems associated with the use of cross-lagged correlations as a way to study causal influences in longitudinal panel data. The current article, however, shows that if stability of constructs is to some extent of a trait-like, timeinvariant nature, the autoregressive relationships of the CLPM fail to adequately account for this. As a result, the lagged parameters that are obtained with the CLPM do not represent the actual within-person relationships over time, and this may lead to erroneous conclusions regarding the presence, predominance, and sign of causal influences. In this article we present an alternative model that separates the within-person process from stable between-person differences through the inclusion of random intercepts, and we discuss how this model is related to existing structural equation models that include cross-lagged relationships. We derive the analytical relationship between the cross-lagged parameters from the CLPM and the alternative model, and use simulations to demonstrate the spurious results that may arise when using the CLPM to analyze data that include stable, trait-like individual differences. We also present a modeling strategy to avoid this pitfall and illustrate this using an empirical data set. The implications for both existing and future cross-lagged panel research are discussed.

Hayes et al.: The relative trustworthiness of inferential tests of the indirect effect in statistical mediation analysis **Hayes-Scharkow-2013**

Andrew F. Hayes and Michael Scharkow. "The relative trustworthiness of inferential tests of the indirect effect in statistical mediation analysis". In: *Psychological Science* 24.10 (Aug. 2013), pp. 1918–1927. DOI: 10.1177/0956797613480187.

Abstract: A content analysis of 2 years of Psychological Science articles reveals inconsistencies in how researchers make inferences about indirect effects when conducting a statistical mediation analysis. In this study, we examined the frequency with which popularly used tests disagree, whether the method an investigator uses makes a difference in the conclusion he or she will reach, and whether there is a most trustworthy test that can be recommended to balance practical and performance considerations. We found that tests agree much more frequently than they disagree, but disagreements are more common when an indirect effect exists than when it does not. We recommend the bias-corrected bootstrap confidence interval as the most trustworthy test if power is of utmost concern, although it can be slightly liberal in some circumstances. Investigators concerned about Type I errors should choose the Monte Carlo confidence interval or the distribution-of-the-product approach, which rarely disagree. The percentile bootstrap confidence interval is a good compromise test.

Hecht et al.: Continuous-time modeling in prevention research: An illustration

Hecht-Voelkle-2019

Martin Hecht and Manuel C. Voelkle. "Continuous-time modeling in prevention research: An illustration". In: *International Journal of Behavioral Development* 45.1 (Nov. 2019), pp. 19–27. ISSN: 1464-0651. DOI: 10.1177/0165025419885026.

Abstract: The analysis of cross-lagged relationships is a popular approach in prevention research to explore the dynamics between constructs over time. However, a limitation of commonly used cross-lagged models is the requirement of equally spaced measurement occasions that prevents the usage of flexible longitudinal designs and complicates cross-study comparisons. Continuous-time modeling overcomes these limitations. In this article, we illustrate the use of continuous-time models using Bayesian and frequentist approaches to model estimation. As an empirical example, we study the dynamic interplay of physical activity and health, a classic research topic in prevention science, using data from the "Midlife in the United States (MIDUS 2): Daily Stress Project, 2004–2009."

To help prevention researchers in adopting the approach, we provide annotated R scripts and a simulated data set based on the results from analyzing the MIDUS 2 data.

Hesterberg: What teachers should know about the bootstrap: Resampling in the undergraduate statistics curriculum **Hesterberg-2015**

Tim C. Hesterberg. "What teachers should know about the bootstrap: Resampling in the undergraduate statistics curriculum". In: *The American Statistician* 69.4 (Oct. 2015), pp. 371–386. DOI: 10.1080/00031305.2015.1089789.

Abstract: Bootstrapping has enormous potential in statistics education and practice, but there are subtle issues and ways to go wrong. For example, the common combination of nonparametric bootstrapping and bootstrap percentile confidence intervals is less accurate than using t-intervals for small samples, though more accurate for larger samples. My goals in this article are to provide a deeper understanding of bootstrap methods–how they work, when they work or not, and which methods work better-and to highlight pedagogical issues. Supplementary materials for this article are available online.

Hingson et al.: Magnitude and trends in heavy episodic drinking, alcohol-impaired driving, and alcohol-related mortality and overdose hospitalizations among emerging adults of college ages 18–24 in the United States, 1998–2014 **Hingson-Zha-Smyth-2017**

Ralph Hingson, Wenxing Zha, and Daniel Smyth. "Magnitude and trends in heavy episodic drinking, alcohol-impaired driving, and alcohol-related mortality and overdose hospitalizations among emerging adults of college ages 18–24 in the United States, 1998–2014". In: *Journal of Studies on Alcohol and Drugs* 78.4 (July 2017), pp. 540–548. ISSN: 1938-4114. DOI: 10.15288/jsad.2017.78.540.

Abstract: Objective: This article estimates percentages of U.S. emerging adults ages 18-24 engaging in past-month heavy episodic drinking and past-year alcohol-impaired driving, and numbers experi-

encing alcohol-related unintentional injury deaths and overdose hospitalizations between 1998 and 2014. Method: We analyzed national injury mortality data from coroner, census, and college enrollment statistics, the National Survey on Drug Use and Health, and the Nationwide Inpatient Sample. Results: From 1999 to 2005, percentages of emerging adults ages 18-24 reporting past-month heavy episodic drinking rose from 37.1% to 43.1% and then declined to 38.8% in 2014. Alcohol-impaired driving rose from 24% to 25.5% and then declined to 16.0%. Alcohol-related unintentional injury deaths increased from 4,807 in 1998 to 5,531 in 2005 and then declined to 4,105 in 2014, a reduction of 29% per 100,000 since 1998. Alcohol-related traffic deaths increased from 3,783 in 1998 to 4,114 in 2005 and then declined to 2,614 in 2014, down 43% per 100,000 since 1998. Alcohol-related overdose deaths increased from 207 in 1998 to 891 in 2014, a 254% increase per 100,000. Other types of nontraffic unintentional injury deaths declined. Alcohol-overdose hospitalizations rose 26% per 100,000 from 1998 to 2014, especially from increases in alcohol/other drug overdoses, up 61% (alcohol/opioid overdoses up 197%). Conclusions: Among emerging adults, a trend toward increased alcohol-related unintentional injury deaths, heavy episodic drinking, and alcohol-impaired driving between 1998 and 2005 was reversed by 2014. Persistent high levels of heavy episodic drinking and related problems among emerging adults underscore a need to expand individually oriented interventions, college/community collaborative programs, and evidence-supported policies to reduce their drinking and related problems.

Hunter: State space modeling in an open source, modular, structural equation modeling environment **Hunter-2017**

Michael D. Hunter. "State space modeling in an open source, modular, structural equation modeling environment". In: *Structural Equation Modeling: A Multidisciplinary Journal* 25.2 (Oct. 2017), pp. 307–324. DOI: 10.1080/10705511.2017.1369354.

Abstract: State space models (SSMs) are introduced in the context of structural equation modeling (SEM). In particular, the OpenMx implementation of SSMs using the Kalman filter and prediction error decomposition is discussed. In reflection of modularity, the implementation uses the same full

information maximum likelihood missing data procedures for SSMs and SEMs. Similarly, generic OpenMx features such as likelihood ratio tests, profile likelihood confidence intervals, Hessian-based standard errors, definition variables, and the matrix algebra interface are all supported. Example scripts for specification of autoregressive models, multiple lag models (VAR(p)), multiple lag moving average models (VARMA(p, q)), multiple subject models, and latent growth models are provided. Additionally, latent variable calculation based on the Kalman filter and raw data generation based on a model are all included. Finally, future work for extending SSMs to allow for random effects and for presenting them in diagrams is discussed.

Jensen et al.: Contributions of psychology to the understanding and treatment of people with chronic pain: Why it matters to ALL psychologists **Jensen-Turk-2014**

Mark P. Jensen and Dennis C. Turk. "Contributions of psychology to the understanding and treatment of people with chronic pain: Why it matters to ALL psychologists". In: *American Psychologist* 69.2 (2014), pp. 105–118. ISSN: 0003-066X. DOI: 10.1037/a0035641.

Abstract: Chronic pain is a prevalent problem with significant costs to individuals, significant others, and society. In this article, which introduces the American Psychologist special issue on chronic pain, we provide an overview of the seminal contributions made by psychologists to our current understanding of this important problem. We also describe the primary treatments that have been developed based on psychological principles and models of pain, many of which have demonstrated efficacy for reducing pain and its impact on psychological and physical functioning. The article ends with an enumeration of directions for future research and clinical practice. We believe that the chronicle of psychology's role in improving our understanding and treatment of pain provides a model for how psychologists can have a significant influence on many fields, and that the models and approaches developed for understanding and treating pain may be of use to psychologists working in other areas. Thus, we think that chronic pain is an important area of study that offers insights about translational research for ALL psychologists.

Jones et al.: Computing confidence intervals for standardized regression coefficients.

Jones-Waller-2013a

Jeff A. Jones and Niels G. Waller. "Computing confidence intervals for standardized regression coefficients." In: *Psychological Methods* 18.4 (2013), pp. 435–453. DOI: 10.1037/a0033269.

Abstract: With fixed predictors, the standard method (Cohen, Cohen, West, & Aiken, 2003, p. 86; Harris, 2001, p. 80; Hays, 1994, p. 709) for computing confidence intervals (CIs) for standardized regression coefficients fails to account for the sampling variability of the criterion standard deviation. With random predictors, this method also fails to account for the sampling variability of the predictor standard deviations. Nevertheless, under some conditions the standard method will produce CIs with accurate coverage rates. To delineate these conditions, we used a Monte Carlo simulation to compute empirical CI coverage rates in samples drawn from 36 populations with a wide range of data characteristics. We also computed the empirical CI coverage rates for 4 alternative methods that have been discussed in the literature: noncentrality interval estimation, the delta method, the percentile bootstrap, and the bias-corrected and accelerated bootstrap. Our results showed that for many data-parameter configurations–for example, sample size, predictor correlations, coefficient of determination (R^2), orientation of β with respect to the eigenvectors of the predictor correlation matrix, R_X–the standard method produced coverage rates that were close to their expected values. However, when population R^2 was large and when β approached the last eigenvector of R_X, then the standard method coverage rates were frequently below the nominal rate (sometimes by a considerable amount). In these conditions, the delta method and the 2 bootstrap procedures were consistently accurate. Results using noncentrality interval estimation were inconsistent. In light of these findings, we recommend that researchers use the delta method to evaluate the sampling variability of standardized regression coefficients.

Jones et al.: The normal-theory and asymptotic distribution-free (ADF) covariance matrix of standardized regression coefficients: Theoretical extensions and finite sample behavior **Jones-Waller-2015**

Jeff A. Jones and Niels G. Waller. "The normal-theory and asymptotic distribution-free (ADF) covariance matrix of standardized regression coefficients: Theoretical extensions and finite sample behavior". In: *Psychometrika* 80.2 (June 2015), pp. 365–378. DOI: 10.1007/s11336-013-9380-y.

Abstract: Yuan and Chan (Psychometrika, 76, 670-690, 2011) recently showed how to compute the covariance matrix of standardized regression coefficients from covariances. In this paper, we describe a method for computing this covariance matrix from correlations. Next, we describe an asymptotic distribution-free (ADF; Browne in British Journal of Mathematical and Statistical Psychology, 37, 62-83, 1984) method for computing the covariance matrix of standardized regression coefficients. We show that the ADF method works well with nonnormal data in moderate-to-large samples using both simulated and real-data examples. R code (R Development Core Team, 2012) is available from the authors or through the Psychometrika online repository for supplementary materials.

Kisbu-Sakarya et al.: The distribution of the product explains normal theory mediation confidence interval estimation **KisbuSakarya-MacKinnon-Miocevic-2014**

Yasemin Kisbu-Sakarya, David P. MacKinnon, and Milica Miočević. "The distribution of the product explains normal theory mediation confidence interval estimation". In: *Multivariate Behavioral Research* 49.3 (May 2014), pp. 261–268. DOI: 10.1080/00273171.2014.903162.

Abstract: The distribution of the product has several useful applications. One of these applications is its use to form confidence intervals for the indirect effect as the product of 2 regression coefficients. The purpose of this article is to investigate how the moments of the distribution of the product explain normal theory mediation confidence interval coverage and imbalance. Values of the critical ratio for each random variable are used to demonstrate how the moments of the distribution of the product change across values of the critical ratio observed in research studies. Results of the simula-

tion study showed that as skewness in absolute value increases, coverage decreases. And as skewness in absolute value and kurtosis increases, imbalance increases. The difference between testing the significance of the indirect effect using the normal theory versus the asymmetric distribution of the product is further illustrated with a real data example. This article is the first study to show the direct link between the distribution of the product and indirect effect confidence intervals and clarifies the results of previous simulation studies by showing why normal theory confidence intervals for indirect effects are often less accurate than those obtained from the asymmetric distribution of the product or from resampling methods.

Koopman et al.: Small sample mediation testing: Misplaced confidence in bootstrapped confidence intervals **Koopman-Howe-Hollenbeck-etal-2015**

Joel Koopman et al. "Small sample mediation testing: Misplaced confidence in bootstrapped confidence intervals". In: *Journal of Applied Psychology* 100.1 (2015), pp. 194–202. DOI: 10.1037/a0036635.

Abstract: Bootstrapping is an analytical tool commonly used in psychology to test the statistical significance of the indirect effect in mediation models. Bootstrapping proponents have particularly advocated for its use for samples of 20-80 cases. This advocacy has been heeded, especially in the Journal of Applied Psychology, as researchers are increasingly utilizing bootstrapping to test mediation with samples in this range. We discuss reasons to be concerned with this escalation, and in a simulation study focused specifically on this range of sample sizes, we demonstrate not only that bootstrapping has insufficient statistical power to provide a rigorous hypothesis test in most conditions but also that bootstrapping has a tendency to exhibit an inflated Type I error rate. We then extend our simulations to investigate an alternative empirical resampling method as well as a Bayesian approach and demonstrate that they exhibit comparable statistical power to bootstrapping in small samples without the associated inflated Type I error. Implications for researchers testing mediation hypotheses in small samples are presented. For researchers wishing

to use these methods in their own research, we have provided R syntax in the online supplemental materials.

Kossakowski et al.: Data from 'Critical Slowing Down as a Personalized Early Warning Signal for Depression' **Kossakowski-Groot-Haslbeck-2017**

Jolanda J. Kossakowski et al. "Data from 'Critical Slowing Down as a Personalized Early Warning Signal for Depression'". In: *Journal of Open Psychology Data* 5 (Feb. 2017). ISSN: 2050-9863. DOI: 10.5334/jopd.29.

Abstract: We present a dataset of a single (N = 1) participant diagnosed with major depressive disorder, who completed 1478 measurements over the course of 239 consecutive days in 2012 and 2013. The experiment included a double-blind phase in which the dosage of anti-depressant medication was gradually reduced. The entire study looked at momentary affective states in daily life before, during, and after the double-blind phase. The items, which were asked ten times a day, cover topics like mood, physical condition and social contacts. Also, depressive symptoms were measured on a weekly basis using the Symptom Checklist Revised (SCL-90-R). The data are suitable for various time-series analyses and studies in complex dynamical systems.

Kuiper et al.: Drawing conclusions from cross-lagged relationships: Re-considering the role of the time-interval **Kuiper-Oisin-2018**

Rebecca M. Kuiper and Oisin Ryan. "Drawing conclusions from cross-lagged relationships: Re-considering the role of the time-interval". In: *Structural Equation Modeling: A Multidisciplinary Journal* 25.5 (Mar. 2018), pp. 809–823. DOI: 10.1080/10705511.2018.1431046.

Abstract: The cross-lagged panel model (CLPM), a discrete-time (DT) SEM model, is frequently used to gather evidence for (reciprocal) Granger-causal relationships when lacking an experimental design. However, it is well known that CLPMs can lead to different parameter estimates depending on the time-interval of observation. Consequently, this can lead to researchers drawing conflicting

conclusions regarding the sign and/or dominance of relationships. Multiple authors have suggested the use of continuous-time models to address this issue. In this article, we demonstrate the exact circumstances under which such conflicting conclusions occur. Specifically, we show that such conflicts are only avoided in general in the case of bivariate, stable, nonoscillating, first-order systems, when comparing models with uniform time-intervals between observations. In addition, we provide a range of tools, proofs, and guidelines regarding the comparison of discrete- and continuous-time parameter estimates.

Kuppens: It's about time: A special section on affect dynamics **Kuppens-2015**

Peter Kuppens. "It's about time: A special section on affect dynamics". In: *Emotion Review* 7.4 (July 2015), pp. 297–300. ISSN: 1754-0747. DOI: 10.1177/1754073915590947.

Abstract: The study of affect dynamics aims to discover the patterns and regularities with which emotions and affective experiences and components change across time, the underlying mechanisms involved, and their potential relevance for healthy psychological functioning. The intention of this special section is to serve as a mini handbook covering the contemporary state of research into affect dynamics. Contributions address theoretical viewpoints on the origins and functions of emotional change, methodological and modeling approaches, biological and social perspectives on affect dynamics, and the downstream consequences for well-being and psychopathology.

Kurtzer et al.: Singularity: Scientific containers for mobility of compute
Kurtzer-Sochat-Bauer-2017

Gregory M. Kurtzer, Vanessa Sochat, and Michael W. Bauer. "Singularity: Scientific containers for mobility of compute". In: *PLOS ONE* 12.5 (May 2017). Ed. by Attila Gursoy, e0177459. DOI: 10.1371/journal.pone.0177459.

Kwan et al.: Comparing standardized coefficients in structural equation modeling: A model reparameterization approach **Kwan-Chan-2011**

Joyce L. Y. Kwan and Wai Chan. "Comparing standardized coefficients in structural equation modeling: A model reparameterization approach". In: *Behavior Research Methods* 43.3 (Apr. 2011), pp. 730–745. DOI: 10.3758/s13428-011-0088-6.

Abstract: We propose a two-stage method for comparing standardized coefficients in structural equation modeling (SEM). At stage 1, we transform the original model of interest into the standardized model by model reparameterization, so that the model parameters appearing in the standardized model are equivalent to the standardized parameters of the original model. At stage 2, we impose appropriate linear equality constraints on the standardized model and use a likelihood ratio test to make statistical inferences about the equality of standardized coefficients. Unlike other existing methods for comparing standardized coefficients, the proposed method does not require specific modeling features (e.g., specification of nonlinear constraints), which are available only in certain SEM software programs. Moreover, this method allows researchers to compare two or more standardized coefficients simultaneously in a standard and convenient way. Three real examples are given to illustrate the proposed method, using EQS, a popular SEM software program. Results show that the proposed method performs satisfactorily for testing the equality of standardized coefficients.

Kwan et al.: Comparing squared multiple correlation coefficients using structural equation modeling **Kwan-Chan-2014**

Joyce L. Y. Kwan and Wai Chan. "Comparing squared multiple correlation coefficients using structural equation modeling". In: *Structural Equation Modeling: A Multidisciplinary Journal* 21.2 (Apr. 2014), pp. 225–238. DOI: 10.1080/10705511.2014.882673.

Abstract: In social science research, a common topic in multiple regression analysis is to compare the squared multiple correlation coefficients in different populations. Existing methods based on

asymptotic theories (Olkin & Finn, 1995) and bootstrapping (Chan, 2009) are available but these can only handle a 2-group comparison. Another method based on structural equation modeling (SEM) has been proposed recently. However, this method has three disadvantages. First, it requires the user to explicitly specify the sample R2 as a function in terms of the basic SEM model parameters, which is sometimes troublesome and error prone. Second, it requires the specification of nonlinear constraints, which is not available in some popular SEM software programs. Third, it is for a 2-group comparison primarily. In this article, a 2-stage SEM method is proposed as an alternative. Unlike all other existing methods, the proposed method is simple to use, and it does not require any specific programming features such as the specification of nonlinear constraints. More important, the method allows a simultaneous comparison of 3 or more groups. A real example is given to illustrate the proposed method using EQS, a popular SEM software program.

Leffingwell et al.: Continuous Objective Monitoring of Alcohol Use: Twenty-First Century Measurement Using Transdermal Sensors Leffingwell-Cooney-Murphy-etal-2012

Thad R. Leffingwell et al. "Continuous Objective Monitoring of Alcohol Use: Twenty-First Century Measurement Using Transdermal Sensors". In: *Alcoholism: Clinical and Experimental Research* 37.1 (July 2012), pp. 16–22. ISSN: 1530-0277. DOI: 10.1111/j.1530-0277.2012.01869.x.

Abstract: Transdermal alcohol sensors continuously collect reliable and valid data on alcohol consumption in vivo over the course of hours to weeks. Transdermal alcohol readings are highly correlated with breath alcohol measurements, but transdermal alcohol levels lag behind breath alcohol levels by one or more hours owing to the longer time required for alcohol to be expelled through perspiration. By providing objective information about alcohol consumption, transdermal alcohol sensors can validate self-report and provide important information not previously available. In this article, we describe the development and evaluation of currently available transdermal alcohol sensors, present the strengths and limitations of the technology, and give examples of recent research using the sensors.

Maxwell et al.: Bias in cross-sectional analyses of longitudinal mediation: Partial and complete mediation under an autoregressive model **Maxwell-Cole-Mitchell-2011**

Scott E. Maxwell, David A. Cole, and Melissa A. Mitchell. "Bias in cross-sectional analyses of longitudinal mediation: Partial and complete mediation under an autoregressive model". In: *Multivariate Behavioral Research* 46.5 (Sept. 2011), pp. 816–841. DOI: 10.1080/00273171.2011.606716.

Abstract: Maxwell and Cole (2007) showed that cross-sectional approaches to mediation typically generate substantially biased estimates of longitudinal parameters in the special case of complete mediation. However, their results did not apply to the more typical case of partial mediation. We extend their previous work by showing that substantial bias can also occur with partial mediation. In particular, cross-sectional analyses can imply the existence of a substantial indirect effect even when the true longitudinal indirect effect is zero. Thus, a variable that is found to be a strong mediator in a cross-sectional analysis may not be a mediator at all in a longitudinal analysis. In addition, we show that very different combinations of longitudinal parameter values can lead to essentially identical cross-sectional correlations, raising serious questions about the interpretability of cross-sectional mediation data. More generally, researchers are encouraged to consider a wide variety of possible mediation models beyond simple cross-sectional models, including but not restricted to autoregressive models of change.

Merkel: Docker: Lightweight Linux containers for consistent development and deployment **Merkel-2014**

Dirk Merkel. "Docker: Lightweight Linux containers for consistent development and deployment". In: *Linux Journal* 2014.239 (2014), p. 2. URL: https://www.linuxjournal.com/content/docker-lightweight-linux-containers-consistent-development-and-deployment.

Miocevic et al.: A tutorial in Bayesian potential outcomes mediation analysis

Miocevic-Gonzalez-Valente-etal-2017

Milica Miocevic et al. "A tutorial in Bayesian potential outcomes mediation analysis". In: *Structural Equation Modeling: A Multidisciplinary Journal* 25.1 (July 2017), pp. 121–136. ISSN: 1532-8007. DOI: 10.1080/10705511.2017.1342541.

Abstract: Statistical mediation analysis is used to investigate intermediate variables in the relation between independent and dependent variables. Causal interpretation of mediation analyses is challenging because randomization of subjects to levels of the independent variable does not rule out the possibility of unmeasured confounders of the mediator to outcome relation. Furthermore, commonly used frequentist methods for mediation analysis compute the probability of the data given the null hypothesis, which is not the probability of a hypothesis given the data as in Bayesian analysis. Under certain assumptions, applying the potential outcomes framework to mediation analysis allows for the computation of causal effects, and statistical mediation in the Bayesian framework gives indirect effects probabilistic interpretations. This tutorial combines causal inference and Bayesian methods for mediation analysis so the indirect and direct effects have both causal and probabilistic interpretations. Steps in Bayesian causal mediation analysis are shown in the application to an empirical example.

Molenaar: Equivalent Dynamic Models **Molenaar-2017**

Peter C. M. Molenaar. "Equivalent Dynamic Models". In: *Multivariate Behavioral Research* 52.2 (Feb. 2017), pp. 242–258. ISSN: 1532-7906. DOI: 10.1080/00273171.2016.1277681.

Abstract: Equivalences of two classes of dynamic models for weakly stationary multivariate time series are discussed: dynamic factor models and autoregressive models. It is shown that exploratory dynamic factor models can be rotated, yielding an infinite set of equivalent solutions for any observed series. It also is shown that dynamic factor models with lagged factor loadings are not equivalent

to the currently popular state-space models, and that restriction of attention to the latter type of models may yield invalid results. The known equivalent vector autoregressive model types, standard and structural, are given a new interpretation in which they are conceived of as the extremes of an innovating type of hybrid vector autoregressive models. It is shown that consideration of hybrid models solves many problems, in particular with Granger causality testing.

Moneta et al.: Causal search in structural vector autoregressive models

Moneta-Chlas-Entner-etal-2011

Alessio Moneta et al. "Causal search in structural vector autoregressive models". In: *Journal of Machine Learning Research - Proceedings Track* 12 (Jan. 2011), pp. 95–114.

Abstract: This paper reviews a class of methods to perform causal inference in the framework of a structural vector autoregressive model. We consider three different settings. In the first setting the underlying system is linear with normal disturbances and the structural model is identified by exploiting the information incorporated in the partial correlations of the estimated residuals. Zero partial correlations are used as input of a search algorithm formalized via graphical causal models. In the second, semi-parametric, setting the underlying system is linear with non-Gaussian disturbances. In this case the structural vector autoregressive model is identified through a search procedure based on independent component analysis. Finally, we explore the possibility of causal search in a nonparametric setting by studying the performance of conditional independence tests based on kernel density estimations.

Neale et al.: OpenMx 2.0: Extended structural equation and statistical modeling

Neale-Hunter-Pritikin-etal-2015

Michael C. Neale et al. "OpenMx 2.0: Extended structural equation and statistical modeling". In: *Psychometrika* 81.2 (Jan. 2015), pp. 535–549. DOI: 10.1007/s11336-014-9435-8.

Abstract: The new software package OpenMx 2.0 for structural equation and other statistical modeling is introduced and its features are described. OpenMx is evolving in a modular direction and now allows a mix-and-match computational approach that separates model expectations from fit functions and optimizers. Major backend architectural improvements include a move to swappable open-source optimizers such as the newly written CSOLNP. Entire new methodologies such as item factor analysis and state space modeling have been implemented. New model expectation functions including support for the expression of models in LISREL syntax and a simplified multigroup expectation function are available. Ease-of-use improvements include helper functions to standardize model parameters and compute their Jacobian-based standard errors, access to model components through standard R $ mechanisms, and improved tab completion from within the R Graphical User Interface.

O'Laughlin et al.: Cross-sectional analysis of longitudinal mediation processes

OLaughlin-Martin-Ferrer-2018

Kristine D. O'Laughlin, Monica J. Martin, and Emilio Ferrer. "Cross-sectional analysis of longitudinal mediation processes". In: *Multivariate Behavioral Research* 53.3 (Apr. 2018), pp. 375–402. ISSN: 1532-7906. DOI: 10.1080/00273171.2018.1454822.

Abstract: Statistical mediation analysis can help to identify and explain the mechanisms behind psychological processes. Examining a set of variables for mediation effects is a ubiquitous process in the social sciences literature; however, despite evidence suggesting that cross-sectional data can misrepresent the mediation of longitudinal processes, cross-sectional analyses continue to be used in this manner. Alternative longitudinal mediation models, including those rooted in a structural equation modeling framework (cross-lagged panel, latent growth curve, and latent difference score models) are currently available and may provide a better representation of mediation processes for longitudinal data. The purpose of this paper is twofold: first, we provide a comparison of cross-sectional and longitudinal mediation models; second, we advocate using models to evaluate mediation effects that capture the temporal sequence of the process under study. Two separate empirical examples

are presented to illustrate differences in the conclusions drawn from cross-sectional and longitudinal mediation analyses. Findings from these examples yielded substantial differences in interpretations between the cross-sectional and longitudinal mediation models considered here. Based on these observations, researchers should use caution when attempting to use cross-sectional data in place of longitudinal data for mediation analyses.

O'Rourke et al.: Reasons for testing mediation in the absence of an intervention effect: A research imperative in prevention and intervention research

ORourke-MacKinnon-2018

Holly P. O'Rourke and David P. MacKinnon. "Reasons for testing mediation in the absence of an intervention effect: A research imperative in prevention and intervention research". In: *Journal of Studies on Alcohol and Drugs* 79.2 (Mar. 2018), pp. 171–181. DOI: 10.15288/jsad.2018.79.171.

Abstract: Objective: Mediation models are used in prevention and intervention research to assess the mechanisms by which interventions influence outcomes. However, researchers may not investigate mediators in the absence of intervention effects on the primary outcome variable. There is emerging evidence that in some situations, tests of mediated effects can be statistically significant when the total intervention effect is not statistically significant. In addition, there are important conceptual and practical reasons for investigating mediation when the intervention effect is nonsignificant. Method: This article discusses the conditions under which mediation may be present when an intervention effect does not have a statistically significant effect and why mediation should always be considered important. Results: Mediation may be present in the following conditions: when the total and mediated effects are equal in value, when the mediated and direct effects have opposing signs, when mediated effects are equal across single and multiple-mediator models, and when specific mediated effects have opposing signs. Mediation should be conducted in every study because it provides the opportunity to test known and replicable mediators, to use mediators as an intervention manipulation check, and to address action and conceptual theory in intervention

models. Conclusions: Mediators are central to intervention programs, and mediators should be investigated for the valuable information they provide about the success or failure of interventions.

O'Rourke et al.: The importance of mediation analysis in substance-use prevention **ORourke-MacKinnon-2019**

Holly P. O'Rourke and David P. MacKinnon. "The importance of mediation analysis in substance-use prevention". In: *Advances in Prevention Science*. Springer International Publishing, 2019, pp. 233–246. DOI: 10.1007/978-3-030-00627-3_15.

Abstract: This chapter describes the theoretical and practical importance of mediation analysis in substance-use prevention research. The most important reason for including mediators in a research study is to examine the mechanisms by which prevention programs influence substance-use outcomes. Understanding the mechanisms by which prevention programs achieve effects helps reduce the cost and increases effectiveness of prevention programs. This chapter first describes the theoretical foundations of the mediation model in prevention, and reasons for using mediation analysis in substance-use prevention. Next, we provide an overview of statistical mediation analysis for single and multiple mediator models. We summarize mediation analyses in substance-use prevention and discuss future directions for application of mediation analysis in substance-use research.

Oravecz et al.: A hierarchical latent stochastic differential equation model for affective dynamics **Oravecz-Tuerlinckx-Vandekerckhove-2011**

Zita Oravecz, Francis Tuerlinckx, and Joachim Vandekerckhove. "A hierarchical latent stochastic differential equation model for affective dynamics". In: *Psychological Methods* 16.4 (2011), pp. 468–490. DOI: 10.1037/a0024375.

Abstract: In this article a continuous-time stochastic model (the Ornstein-Uhlenbeck process) is presented to model the perpetually altering states of the core affect, which is a 2-dimensional concept underlying all our affective experiences. The process model that we propose can account

for the temporal changes in core affect on the latent level. The key parameters of the model are the average position (also called home base), the variances and covariances of the process, and the regulatory mechanisms that keep the process in the vicinity of the average position. To account for individual differences, the model is extended hierarchically. A particularly novel contribution is that in principle all parameters of the stochastic process (not only the mean but also its variance and the regulatory parameters) are allowed to differ between individuals. In this way, the aim is to understand the affective dynamics of single individuals and at the same time investigate how these individuals differ from one another. The final model is a continuous-time state-space model for repeated measurement data taken at possibly irregular time points. Both time-invariant and time-varying covariates can be included to investigate sources of individual differences. As an illustration, the model is applied to a diary study measuring core affect repeatedly for several individuals (thereby generating intensive longitudinal data).

Ou et al.: What's for dynr: A package for linear and nonlinear dynamic modeling in R **Ou-Hunter-Chow-2019**

Lu Ou, Michael D. Hunter, and Sy-Miin Chow. "What's for dynr: A package for linear and nonlinear dynamic modeling in R". In: *The R Journal* 11.1 (2019), p. 91. DOI: 10.32614/rj-2019-012.

Abstract: Intensive longitudinal data in the behavioral sciences are often noisy, multivariate in nature, and may involve multiple units undergoing regime switches by showing discontinuities interspersed with continuous dynamics. Despite increasing interest in using linear and nonlinear differential/difference equation models with regime switches, there has been a scarcity of software packages that are fast and freely accessible. We have created an R package called dynr that can handle a broad class of linear and nonlinear discreteand continuous-time models, with regime-switching properties and linear Gaussian measurement functions, in C, while maintaining simple and easy-to learn model specification functions in R. We present the mathematical and computational bases used by the dynr R package, and present two illustrative examples to demonstrate the unique features of dynr.

Thomas M. Piasecki. "Assessment of alcohol use in the natural environment". In: *Alcoholism: Clinical and Experimental Research* 43.4 (Mar. 2019), pp. 564–577. ISSN: 1530-0277. DOI: 10.1111/acer.13975.

Abstract: The current article critically reviews 3 methodological options for assessing drinking episodes in the natural environment. Ecological momentary assessment (EMA) typically involves using mobile devices to collect self-report data from participants in daily life. This technique is now widely used in alcohol research, but investigators have implemented diverse assessment strategies. This article focuses on "high-resolution" EMA protocols that oversample experiences and behaviors within individual drinking episodes. A number of approaches have been used to accomplish this, including using signaled follow-ups tied to drinking initiation, asking participants to log entries before and after individual drinks or drinking episodes, and delivering frequent signaled assessments during periods of the day when alcohol use is most common. Transdermal alcohol sensors (TAS) are devices that are worn continuously and are capable of detecting alcohol eliminated through the skin. These methods are appealing because they do not rely upon drinkers' self-report. Studies using TAS have been appearing with greater frequency over the past several years. New methods are making the use of TAS more tractable by permitting back-translation of transdermal alcohol concentration data to more familiar estimates of blood alcohol concentration or breath alcohol concentration. However, the current generation of devices can have problems with missing data and tend to be relatively insensitive to low-level drinking. An emerging area of research investigates the possibility of using mobile device data and machine learning to passively detect the user's drinking, with promising early findings. EMA, TAS, and sensor-based approaches are all valid, and tend to produce convergent information when used in conjunction with one another. Each has a unique profile of advantages, disadvantages, and threats to validity. Therefore, the nature of the underlying research question must dictate the method(s) investigators select.

Preacher et al.: Effect size measures for mediation models: Quantitative strategies for communicating indirect effects **Preacher-Kelley-2011**

Kristopher J. Preacher and Ken Kelley. "Effect size measures for mediation models: Quantitative strategies for communicating indirect effects". In: *Psychological Methods* 16.2 (2011), pp. 93–115. ISSN: 1082-989X. DOI: 10.1037/a0022658.

Abstract: The statistical analysis of mediation effects has become an indispensable tool for helping scientists investigate processes thought to be causal. Yet, in spite of many recent advances in the estimation and testing of mediation effects, little attention has been given to methods for communicating effect size and the practical importance of those effect sizes. Our goals in this article are to (a) outline some general desiderata for effect size measures, (b) describe current methods of expressing effect size and practical importance for mediation, (c) use the desiderata to evaluate these methods, and (d) develop new methods to communicate effect size in the context of mediation analysis. The first new effect size index we describe is a residual-based index that quantifies the amount of variance explained in both the mediator and the outcome. The second new effect size index quantifies the indirect effect as the proportion of the maximum possible indirect effect that could have been obtained, given the scales of the variables involved. We supplement our discussion by offering easy-to-use R tools for the numerical and visual communication of effect size for mediation effects.

Preacher et al.: Advantages of Monte Carlo confidence intervals for indirect effects **Preacher-Selig-2012**

Kristopher J. Preacher and James P. Selig. "Advantages of Monte Carlo confidence intervals for indirect effects". In: *Communication Methods and Measures* 6.2 (Apr. 2012), pp. 77–98. DOI: 10.1080/19312458.2012.679848.

Abstract: Monte Carlo simulation is a useful but underutilized method of constructing confidence intervals for indirect effects in mediation analysis. The Monte Carlo confidence interval method

has several distinct advantages over rival methods. Its performance is comparable to other widely accepted methods of interval construction, it can be used when only summary data are available, it can be used in situations where rival methods (e.g., bootstrapping and distribution of the product methods) are difficult or impossible, and it is not as computer-intensive as some other methods. In this study we discuss Monte Carlo confidence intervals for indirect effects, report the results of a simulation study comparing their performance to that of competing methods, demonstrate the method in applied examples, and discuss several software options for implementation in applied settings.

Reichardt: Commentary: Are three waves of data sufficient for assessing mediation? **Reichardt-2011**

Charles S. Reichardt. "Commentary: Are three waves of data sufficient for assessing mediation?" In: *Multivariate Behavioral Research* 46.5 (Sept. 2011), pp. 842–851. ISSN: 1532-7906. DOI: 10.1080/00273171.2011.606740.

Abstract: Maxwell, Cole, and Mitchell (2011) demonstrated that simple structural equation models, when used with cross-sectional data, generally produce biased estimates of meditated effects. I extend those results by showing how simple structural equation models can produce biased estimates of meditated effects when used even with longitudinal data. Even with longitudinal data, simple autoregressive structural equation models can imply the existence of indirect effects when only direct effects exist and the existence of direct effects when only indirect effects exist.

Rosseel: lavaan: An R package for structural equation modeling **Rosseel-2012**

Yves Rosseel. "lavaan: An R package for structural equation modeling". In: *Journal of Statistical Software* 48.2 (2012). DOI: 10.18637/jss.v048.i02.

Abstract: Structural equation modeling (SEM) is a vast field and widely used by many applied researchers in the social and behavioral sciences. Over the years, many software packages for struc-

tural equation modeling have been developed, both free and commercial. However, perhaps the best state-of-the-art software packages in this field are still closed-source and/or commercial. The R package lavaan has been developed to provide applied researchers, teachers, and statisticians, a free, fully open-source, but commercial-quality package for latent variable modeling. This paper explains the aims behind the development of the package, gives an overview of its most important features, and provides some examples to illustrate how lavaan works in practice.

Sacks et al.: 2010 national and state costs of excessive alcohol consumption

Sacks-Gonzales-Bouchery-etal-2015

Jeffrey J. Sacks et al. "2010 national and state costs of excessive alcohol consumption". In: *American Journal of Preventive Medicine* 49.5 (Nov. 2015), e73–e79. ISSN: 0749-3797. DOI: 10.1016/j.amepre.2015.05.031.

Abstract: Introduction: Excessive alcohol use cost the U.S. 223.5*billionin*2006.*Giveneconomicshiftsin theU.S.since*2006, *currentestimatesareneededtohelpinformtheplanningofpreventionstrategies.Methods* : *FromMarch*2012*toMarch*201 *attributabledeaths*)*and price*(*e.g.*, *inflationrateincostofmedicalcare*).*Thetotalcost*, *costtogovernment*, *andcostsforbing* *ExcessivedrinkingcosttheU.S.*249.0 billion in 2010, or about 2.05*perdrink.Governmentpaidfor*100.7 billion (40.4%) of these costs. Binge drinking accounted for 191.1*billion*(76.7%)*ofcosts*; *underagedrinking*24.3 billion (9.7%) of costs; and drinking while pregnant 5.5*billion*(2.2%)*ofcosts.Themediancostperstatewas*3.5 billion. Binge drinking was responsible for ¿70% of these costs in all states, and ¿40% of the binge drinking–related costs were paid by government. Conclusions: Excessive drinking cost the nation almost 250*billionin*2010.*Twoofevery*5 of the total cost was paid by government, and three quarters of the costs were due to binge drinking. Several evidence-based strategies can help reduce excessive drinking and related costs, including increasing alcohol excise taxes, limiting alcohol outlet density, and commercial host liability.

Schermerhorn et al.: Developmental family processes and interparental conflict: Patterns of microlevel influences. Schermerhorn-Chow-Cummings-2010

Alice C. Schermerhorn, Sy-Miin Chow, and E. Mark Cummings. "Developmental family processes and interparental conflict: Patterns of microlevel influences." In: *Developmental Psychology* 46.4 (2010), pp. 869–885. ISSN: 0012-1649. DOI: 10.1037/a0019662.

Abstract: Although there are frequent calls for the study of effects of children on families and mutual influence processes within families, little empirical progress has been made. We address these questions at the level of microprocesses during marital conflict, including children's influence on marital conflict and parents' influence on each other. Participants were 111 cohabiting couples with a child (55 male, 56 female) age 8–16 years. Data were drawn from parents' diary reports of interparental conflict over 15 days and were analyzed with dynamic systems modeling tools. Child emotions and behavior during conflicts were associated with interparental positivity, negativity, and resolution at the end of the same conflicts. For example, children's agentic behavior was associated with more marital conflict resolution, whereas child negativity was linked with more marital negativity. Regarding parents' influence on each other, among the findings, husbands' and wives' influence on themselves from one conflict to the next was indicated, and total number of conflicts predicted greater influence of wives' positivity on husbands' positivity. Contributions of these findings to the understanding of developmental family processes are discussed, including implications for advanced understanding of interrelations between child and adult functioning and development.

Schouten et al.: Generating missing values for simulation purposes: A multivariate amputation procedure Schouten-Lugtig-Vink-2018

Rianne Margaretha Schouten, Peter Lugtig, and Gerko Vink. "Generating missing values for simulation purposes: A multivariate amputation procedure". In: *Journal of Statistical Computation and Simulation* 88.15 (July 2018), pp. 2909–2930. DOI: 10.1080/00949655.2018.1491577.

Abstract: Missing data form a ubiquitous problem in scientific research, especially since most statistical analyses require complete data. To evaluate the performance of methods dealing with missing data, researchers perform simulation studies. An important aspect of these studies is the generation of missing values in a simulated, complete data set: the amputation procedure. We investigated the methodological validity and statistical nature of both the current amputation practice and a newly developed and implemented multivariate amputation procedure. We found that the current way of practice may not be appropriate for the generation of intuitive and reliable missing data problems. The multivariate amputation procedure, on the other hand, generates reliable amputations and allows for a proper regulation of missing data problems. The procedure has additional features to generate any missing data scenario precisely as intended. Hence, the multivariate amputation procedure is an efficient method to accurately evaluate missing data methodology.

Schultzberg et al.: Number of subjects and time points needed for multilevel time-series analysis: A simulation study of dynamic structural equation modeling

Schultzberg-Muthen-2017

Mårten Schultzberg and Bengt Muthén. "Number of subjects and time points needed for multilevel time-series analysis: A simulation study of dynamic structural equation modeling". In: *Structural Equation Modeling: A Multidisciplinary Journal* 25.4 (Dec. 2017), pp. 495–515. ISSN: 1532-8007. DOI: 10.1080/10705511.2017.1392862.

Abstract: Dynamic structural equation modeling (DSEM) is a novel, intensive longitudinal data (ILD) analysis framework. DSEM models intraindividual changes over time on Level 1 and allows the parameters of these processes to vary across individuals on Level 2 using random effects. DSEM merges time series, structural equation, multilevel, and time-varying effects models. Despite the well-known properties of these analysis areas by themselves, it is unclear how their sample size requirements and recommendations transfer to the DSEM framework. This article presents the results of a simulation study that examines the estimation quality of univariate 2-level autoregressive models of order 1, AR(1), using Bayesian analysis in Mplus Version 8. Three features are varied

in the simulations: complexity of the model, number of subjects, and number of time points per subject. Samples with many subjects and few time points are shown to perform substantially better than samples with few subjects and many time points.

Schuurman et al.: Measurement error and person-specific reliability in multilevel autoregressive modeling. **Schuurman-Hamaker-2019**

Noémi K. Schuurman and Ellen L. Hamaker. "Measurement error and person-specific reliability in multilevel autoregressive modeling." In: *Psychological Methods* 24.1 (Feb. 2019), pp. 70–91. ISSN: 1082-989X. DOI: 10.1037/met0000188.

Abstract: An increasing number of researchers in psychology are collecting intensive longitudinal data in order to study psychological processes on an intraindividual level. An increasingly popular way to analyze these data is autoregressive time series modeling; either by modeling the repeated measures for a single individual using classic n = 1 autoregressive models, or by using multilevel extensions of these models, with the dynamics for each individual modeled at Level 1 and interindividual differences in these dynamics modeled at Level 2. However, while it is widely accepted in psychology that psychological measurements usually contain a certain amount of measurement error, the issue of measurement error is largely neglected in applied psychological (autoregressive) time series modeling: The regular autoregressive model incorporates innovations, or "dynamic errors," but not measurement error. In this article we discuss the concepts of reliability and measurement error in the context of dynamic (VAR(1)) models, and the consequences of disregarding measurement error variance in the data. For this purpose, we present a preliminary model that accounts for measurement error for constructs that are measured with a single indicator. We further discuss how this model could be used to investigate the between-person reliability of the measurements, as well as the (person-specific) within-person reliabilities and any individual differences in these reliabilities. We illustrate the consequences of assuming perfect reliability, the preliminary model, and reliabilities, using an empirical application in which we relate women's general positive affect to their positive affect concerning their romantic relationship.

Schuurman et al.: Incorporating measurement error in n = 1 psychological autoregressive modeling **Schuurman-Houtveen-Hamaker-2015**

Noémi K. Schuurman, Jan H. Houtveen, and Ellen L. Hamaker. "Incorporating measurement error in n = 1 psychological autoregressive modeling". In: *Frontiers in Psychology* 6 (July 2015). ISSN: 1664-1078. DOI: 10.3389/fpsyg.2015.01038.

Abstract: Measurement error is omnipresent in psychological data. However, the vast majority of applications of autoregressive time series analyses in psychology do not take measurement error into account. Disregarding measurement error when it is present in the data results in a bias of the autoregressive parameters. We discuss two models that take measurement error into account: An autoregressive model with a white noise term (AR+WN), and an autoregressive moving average (ARMA) model. In a simulation study we compare the parameter recovery performance of these models, and compare this performance for both a Bayesian and frequentist approach. We find that overall, the AR+WN model performs better. Furthermore, we find that for realistic (i.e., small) sample sizes, psychological research would benefit from a Bayesian approach in fitting these models. Finally, we illustrate the effect of disregarding measurement error in an AR(1) model by means of an empirical application on mood data in women. We find that, depending on the person, approximately 30-50% of the total variance was due to measurement error, and that disregarding this measurement error results in a substantial underestimation of the autoregressive parameters.

Shrout: Commentary: Mediation analysis, causal process, and cross-sectional data **Shrout-2011**

Patrick E. Shrout. "Commentary: Mediation analysis, causal process, and cross-sectional data". In: *Multivariate Behavioral Research* 46.5 (Sept. 2011), pp. 852–860. DOI: 10.1080/00273171.2011.606718.

Abstract: Maxwell, Cole, and Mitchell (2011) extended the work of Maxwell and Cole (2007), which raised important questions about whether mediation analyses based on cross-sectional data

can shed light on longitudinal mediation process. The latest article considers longitudinal processes that can only be partially explained by an intervening variable, and Maxwell et al. showed that the same general conclusions are obtained, namely that analyses of cross-sectional data will not reveal the longitudinal mediation process. While applauding the advances of the target article, this comment encourages the detailed exploration of alternate causal models in psychology beyond the autoregressive model considered by Maxwell et al. When inferences based on cross-sectional analyses are compared to alternate models, different patterns of bias are likely to be observed. I illustrate how different models of the causal process can be derived using examples from research on psychopathology.

Singer: SEM modeling with singular moment matrices part II: ML-estimation of sampled stochastic differential equations **Singer-2012**

Hermann Singer. "SEM modeling with singular moment matrices part II: ML-estimation of sampled stochastic differential equations". In: *The Journal of Mathematical Sociology* 36.1 (Jan. 2012), pp. 22–43. ISSN: 1545-5874. DOI: 10.1080/0022250x.2010.532259.

Abstract: Linear stochastic differential equations are expressed as an exact discrete model (EDM) and estimated with structural equation models (SEMs) and the Kalman filter (KF) algorithm. The oversampling approach is introduced in order to formulate the EDM on a time grid which is finer than the sampling intervals. This leads to a simple computation of the nonlinear parameter functionals of the EDM. For small discretization intervals, the functionals can be linearized, and standard software permitting only linear parameter restrictions can be used. However, in this case the SEM approach must handle large matrices leading to degraded performance and possible numerical problems. The methods are compared using coupled linear random oscillators with time-varying parameters and irregular sampling times.

Smith et al.: From ecological momentary assessment (EMA) to ecological momentary intervention (EMI): Past and future directions for ambulatory assessment and interventions in eating disorders **Smith-Juarascio-2019**

Kathryn E. Smith and Adrienne Juarascio. "From ecological momentary assessment (EMA) to ecological momentary intervention (EMI): Past and future directions for ambulatory assessment and interventions in eating disorders". In: *Current Psychiatry Reports* 21.7 (June 2019). DOI: 10.1007/s11920-019-1046-8.

Abstract: Purpose of Review: Ambulatory assessment methods, including ecological momentary assessment (EMA), have often been used in eating disorders (EDs) to assess the type, frequency, and temporal sequencing of ED symptoms occurring in naturalistic environments. Relatedly, growing research in EDs has explored the utility of ecological momentary interventions (EMIs) to target ED symptoms. The aims of the present review were to (1) synthesize recent literature pertaining to ambulatory assessment/EMA and EMI in EDs, and (2) identify relevant limitations and future directions in these domains. Recent Findings: With respect to ambulatory assessment and EMA, there has been substantial growth in the expansion of constructs assessed with EMA, the exploration of state- vs. trait-level processes, integration of objective and passive assessment approaches, and consideration of methodological issues. The EMI literature in EDs also continues to grow, though most of the recent research focuses on mobile health (mHealth) technologies with relatively minimal EMI components that adapt to momentary contextual information. Summary: Despite these encouraging advances, there remain several promising areas of ambulatory assessment research and clinical applications in EDs going forward. These include integration of passive data collection, use of EMA in treatment evaluation and design, evaluation of dynamic system processes, inclusion of diverse samples, and development and evaluation of adaptive, tailored EMIs such as just-in-time adaptive interventions. While much remains to be learned in each of these domains, the continual growth in mobile technology has potential to facilitate and refine our understanding of the nature of ED psychopathology and ultimately improve intervention approaches.

Taylor et al.: Four applications of permutation methods to testing a single-mediator model **Taylor-MacKinnon-2012**

Aaron B. Taylor and David P. MacKinnon. "Four applications of permutation methods to testing a single-mediator model". In: *Behavior Research Methods* 44.3 (Feb. 2012), pp. 806–844. DOI: 10.3758/s13428-011-0181-x.

Abstract: Four applications of permutation tests to the single-mediator model are described and evaluated in this study. Permutation tests work by rearranging data in many possible ways in order to estimate the sampling distribution for the test statistic. The four applications to mediation evaluated here are the permutation test of ab, the permutation joint significance test, and the noniterative and iterative permutation confidence intervals for ab. A Monte Carlo simulation study was used to compare these four tests with the four best available tests for mediation found in previous research: the joint significance test, the distribution of the product test, and the percentile and bias-corrected bootstrap tests. We compared the different methods on Type I error, power, and confidence interval coverage. The noniterative permutation confidence interval for ab was the best performer among the new methods. It successfully controlled Type I error, had power nearly as good as the most powerful existing methods, and had better coverage than any existing method. The iterative permutation confidence interval for ab had lower power than do some existing methods, but it performed better than any other method in terms of coverage. The permutation confidence interval methods are recommended when estimating a confidence interval is a primary concern. SPSS and SAS macros that estimate these confidence intervals are provided.

Tibshirani: Regression shrinkage and selection via the lasso: A retrospective **Tibshirani-2011**

Robert Tibshirani. "Regression shrinkage and selection via the lasso: A retrospective". In: *Journal of the Royal Statistical Society Series B: Statistical Methodology* 73.3 (Apr. 2011), pp. 273–282. ISSN: 1467-9868. DOI: 10.1111/j.1467-9868.2011.00771.x.

Abstract: In the paper I give a brief review of the basic idea and some history and then discuss some developments since the original paper on regression shrinkage and selection via the lasso.

Tofighi et al.: Indirect effects in sequential mediation models: Evaluating methods for hypothesis testing and confidence interval formation **Tofighi-Kelley-2019**

Davood Tofighi and Ken Kelley. "Indirect effects in sequential mediation models: Evaluating methods for hypothesis testing and confidence interval formation". In: *Multivariate Behavioral Research* 55.2 (June 2019), pp. 188–210. DOI: 10.1080/00273171.2019.1618545.

Abstract: Complex mediation models, such as a two-mediator sequential model, have become more prevalent in the literature. To test an indirect effect in a two-mediator model, we conducted a large-scale Monte Carlo simulation study of the Type I error, statistical power, and confidence interval coverage rates of 10 frequentist and Bayesian confidence/credible intervals (CIs) for normally and nonnormally distributed data. The simulation included never-studied methods and conditions (e.g., Bayesian CI with flat and weakly informative prior methods, two model-based bootstrap methods, and two nonnormality conditions) as well as understudied methods (e.g., profile-likelihood, Monte Carlo with maximum likelihood standard error [MC-ML] and robust standard error [MC-Robust]). The popular BC bootstrap showed inflated Type I error rates and CI under-coverage. We recommend different methods depending on the purpose of the analysis. For testing the null hypothesis of no mediation, we recommend MC-ML, profile-likelihood, and two Bayesian methods. To report a CI, if data has a multivariate normal distribution, we recommend MC-ML, profile-likelihood, and the two Bayesian methods; otherwise, for multivariate nonnormal data we recommend the percentile bootstrap. We argue that the best method for testing hypotheses is not necessarily the best method for CI construction, which is consistent with the findings we present.

Tofighi et al.: Monte Carlo confidence intervals for complex functions of indirect effects **Tofighi-MacKinnon-2015**

Davood Tofighi and David P. MacKinnon. "Monte Carlo confidence intervals for complex functions of indirect effects". In: *Structural Equation Modeling: A Multidisciplinary Journal* 23.2 (Aug. 2015), pp. 194–205. DOI: 10.1080/10705511.2015.1057284.

Abstract: One challenge in mediation analysis is to generate a confidence interval (CI) with high coverage and power that maintains a nominal significance level for any well-defined function of indirect and direct effects in the general context of structural equation modeling (SEM). This study discusses a proposed Monte Carlo extension that finds the CIs for any well-defined function of the coefficients of SEM such as the product of k coefficients and the ratio of the contrasts of indirect effects, using the Monte Carlo method. Finally, we conduct a small-scale simulation study to compare CIs produced by the Monte Carlo, nonparametric bootstrap, and asymptotic-delta methods. Based on our simulation study, we recommend researchers use the Monte Carlo method to test a complex function of indirect effects.

Usami et al.: A unified framework of longitudinal models to examine reciprocal relations **Usami-Murayama-Hamaker-2019**

Satoshi Usami, Kou Murayama, and Ellen L. Hamaker. "A unified framework of longitudinal models to examine reciprocal relations". In: *Psychological Methods* 24.5 (Oct. 2019), pp. 637–657. ISSN: 1082-989X. DOI: 10.1037/met0000210.

Abstract: Inferring reciprocal effects or causality between variables is a central aim of behavioral and psychological research. To address reciprocal effects, a variety of longitudinal models that include cross-lagged relations have been proposed in different contexts and disciplines. However, the relations between these cross-lagged models have not been systematically discussed in the literature. This lack of insight makes it difficult for researchers to select an appropriate model

when analyzing longitudinal data, and some researchers do not even think about alternative cross-lagged models. The present research provides a unified framework that clarifies the conceptual and mathematical similarities and differences between these models. The unified framework shows that existing longitudinal models can be effectively classified based on whether the model posits unique factors and/or dynamic residuals and what types of common factors are used to model changes. The latter is essential to understand how cross-lagged parameters are interpreted. We also present an example using empirical data to demonstrate that there is great risk of drawing different conclusions depending on the cross-lagged models used.

van Buuren et al.: mice: Multivariate Imputation by Chained Equations in R

vanBuuren-GroothuisOudshoorn-2011

Stef van Buuren and Karin Groothuis-Oudshoorn. "mice: Multivariate Imputation by Chained Equations in R". In: *Journal of Statistical Software* 45.3 (2011). DOI: 10.18637/jss.v045.i03.

Abstract: The R package mice imputes incomplete multivariate data by chained equations. The software mice 1.0 appeared in the year 2000 as an S-PLUS library, and in 2001 as an R package. mice 1.0 introduced predictor selection, passive imputation and automatic pooling. This article documents mice, which extends the functionality of mice 1.0 in several ways. In mice, the analysis of imputed data is made completely general, whereas the range of models under which pooling works is substantially extended. mice adds new functionality for imputing multilevel data, automatic predictor selection, data handling, post-processing imputed values, specialized pooling routines, model selection tools, and diagnostic graphs. Imputation of categorical data is improved in order to bypass problems caused by perfect prediction. Special attention is paid to transformations, sum scores, indices and interactions using passive imputation, and to the proper setup of the predictor matrix. mice can be downloaded from the Comprehensive R Archive Network. This article provides a hands-on, stepwise approach to solve applied incomplete data problems.

Ver Hoef: Who invented the delta method? **VerHoef-2012**

Jay M. Ver Hoef. "Who invented the delta method?" In: *The American Statistician* 66.2 (May 2012), pp. 124–127. ISSN: 1537-2731. DOI: 10.1080/00031305.2012.687494.

Abstract: Many statisticians and other scientists use what is commonly called the "delta method." However, few people know who proposed it. The earliest article was found in an obscure journal, and the author is rarely cited for his contribution. This article briefly reviews three modern versions of the delta method and how they are used. Then, some history on the author and the journal of the first known article on the delta method is given. The original author's specific contribution is reproduced, along with a discussion on possible reasons that it has been overlooked.

Voelkle et al.: Continuous time modelling with individually varying time intervals for oscillating and non-oscillating processes **Voelkle-Oud-2012**

Manuel C. Voelkle and Johan H. L. Oud. "Continuous time modelling with individually varying time intervals for oscillating and non-oscillating processes". In: *British Journal of Mathematical and Statistical Psychology* 66.1 (Mar. 2012), pp. 103–126. DOI: 10.1111/j.2044-8317.2012.02043.x.

Abstract: When designing longitudinal studies, researchers often aim at equal intervals. In practice, however, this goal is hardly ever met, with different time intervals between assessment waves and different time intervals between individuals being more the rule than the exception. One of the reasons for the introduction of continuous time models by means of structural equation modelling has been to deal with irregularly spaced assessment waves (e.g., Oud & Delsing, 2010). In the present paper we extend the approach to individually varying time intervals for oscillating and non-oscillating processes. In addition, we show not only that equal intervals are unnecessary but also that it can be advantageous to use unequal sampling intervals, in particular when the sampling rate is low. Two examples are provided to support our arguments. In the first example we compare a continuous time model of a bivariate coupled process with varying time intervals to a standard discrete time

model to illustrate the importance of accounting for the exact time intervals. In the second example the effect of different sampling intervals on estimating a damped linear oscillator is investigated by means of a Monte Carlo simulation. We conclude that it is important to account for individually varying time intervals, and encourage researchers to conceive of longitudinal studies with different time intervals within and between individuals as an opportunity rather than a problem.

Voelkle et al.: An SEM approach to continuous time modeling of panel data: Relating authoritarianism and anomia **Voelkle-Oud-Davidov-etal-2012**

Manuel C. Voelkle, Johan H. L. Oud, et al. "An SEM approach to continuous time modeling of panel data: Relating authoritarianism and anomia". In: *Psychological Methods* 17.2 (2012), pp. 176–192. DOI: 10.1037/a0027543.

Abstract: Panel studies, in which the same subjects are repeatedly observed at multiple time points, are among the most popular longitudinal designs in psychology. Meanwhile, there exists a wide range of different methods to analyze such data, with autoregressive and cross-lagged models being 2 of the most well known representatives. Unfortunately, in these models time is only considered implicitly, making it difficult to account for unequally spaced measurement occasions or to compare parameter estimates across studies that are based on different time intervals. Stochastic differential equations offer a solution to this problem by relating the discrete time model to its underlying model in continuous time. It is the goal of the present article to introduce this approach to a broader psychological audience. A step-by-step review of the relationship between discrete and continuous time modeling is provided, and we demonstrate how continuous time parameters can be obtained via structural equation modeling. An empirical example on the relationship between authoritarianism and anomia is used to illustrate the approach.

Vuorre et al.: Within-subject mediation analysis for experimental data in cognitive psychology and neuroscience **Vuorre-Bolger-2017**

Matti Vuorre and Niall Bolger. "Within-subject mediation analysis for experimental data in cognitive psychology and neuroscience". In: *Behavior Research Methods* 50.5 (Dec. 2017), pp. 2125–2143. ISSN: 1554-3528. DOI: 10.3758/s13428-017-0980-9.

Abstract: Statistical mediation allows researchers to investigate potential causal effects of experimental manipulations through intervening variables. It is a powerful tool for assessing the presence and strength of postulated causal mechanisms. Although mediation is used in certain areas of psychology, it is rarely applied in cognitive psychology and neuroscience. One reason for the scarcity of applications is that these areas of psychology commonly employ within-subjects designs, and mediation models for within-subjects data are considerably more complicated than for between-subjects data. Here, we draw attention to the importance and ubiquity of mediational hypotheses in within-subjects designs, and we present a general and flexible software package for conducting Bayesian within-subjects mediation analyses in the R programming environment. We use experimental data from cognitive psychology to illustrate the benefits of within-subject mediation for theory testing and comparison.

Wichers et al.: Critical slowing down as a personalized early warning signal for depression **Wichers-Groot-Psychosystems-2016**

Marieke Wichers et al. "Critical slowing down as a personalized early warning signal for depression". In: *Psychotherapy and Psychosomatics* 85.2 (2016), pp. 114–116. ISSN: 1423-0348. DOI: 10.1159/000441458.

Wu et al.: A new procedure to test mediation with missing data through nonparametric bootstrapping and multiple imputation **Wu-Jia-2013**

Wei Wu and Fan Jia. "A new procedure to test mediation with missing data through nonparametric

bootstrapping and multiple imputation". In: *Multivariate Behavioral Research* 48.5 (Sept. 2013), pp. 663–691. DOI: 10.1080/00273171.2013.816235.

Abstract: This article proposes a new procedure to test mediation with the presence of missing data by combining nonparametric bootstrapping with multiple imputation (MI). This procedure performs MI first and then bootstrapping for each imputed data set. The proposed procedure is more computationally efficient than the procedure that performs bootstrapping first and then MI for each bootstrap sample. The validity of the procedure is evaluated using a simulation study under different sample size, missing data mechanism, missing data proportion, and shape of distribution conditions. The result suggests that the proposed procedure performs comparably to the procedure that combines bootstrapping with full information maximum likelihood under most conditions. However, caution needs to be taken when using this procedure to handle missing not-at-random or nonnormal data.

Yuan et al.: Biases and standard errors of standardized regression coefficients

Yuan-Chan-2011

Ke-Hai Yuan and Wai Chan. "Biases and standard errors of standardized regression coefficients". In: *Psychometrika* 76.4 (Aug. 2011), pp. 670–690. DOI: 10.1007/s11336-011-9224-6.

Abstract: The paper obtains consistent standard errors (SE) and biases of order O(1/n) for the sample standardized regression coefficients with both random and given predictors. Analytical results indicate that the formulas for SEs given in popular text books are consistent only when the population value of the regression coefficient is zero. The sample standardized regression coefficients are also biased in general, although it should not be a concern in practice when the sample size is not too small. Monte Carlo results imply that, for both standardized and unstandardized sample regression coefficients, SE estimates based on asymptotics tend to under-predict the empirical ones at smaller sample sizes.

Yzerbyt et al.: New recommendations for testing indirect effects in mediational models: The need to report and test component paths **Yzerbyt-Muller-Batailler-etal-2018**

Vincent Yzerbyt et al. "New recommendations for testing indirect effects in mediational models: The need to report and test component paths". In: *Journal of Personality and Social Psychology* 115.6 (Dec. 2018), pp. 929–943. DOI: 10.1037/pspa0000132.

Abstract: In light of current concerns with replicability and reporting false-positive effects in psychology, we examine Type I errors and power associated with 2 distinct approaches for the assessment of mediation, namely the component approach (testing individual parameter estimates in the model) and the index approach (testing a single mediational index). We conduct simulations that examine both approaches and show that the most commonly used tests under the index approach risk inflated Type I errors compared with the joint-significance test inspired by the component approach. We argue that the tendency to report only a single mediational index is worrisome for this reason and also because it is often accompanied by a failure to critically examine the individual causal paths underlying the mediational model. We recommend testing individual components of the indirect effect to argue for the presence of an indirect effect and then using other recommended procedures to calculate the size of that effect. Beyond simple mediation, we show that our conclusions also apply in cases of within-participant mediation and moderated mediation. We also provide a new R-package that allows for an easy implementation of our recommendations.

Zhang et al.: Methods for mediation analysis with missing data **Zhang-Wang-2012**

Zhiyong Zhang and Lijuan Wang. "Methods for mediation analysis with missing data". In: *Psychometrika* 78.1 (Dec. 2012), pp. 154–184. DOI: 10.1007/s11336-012-9301-5.

Abstract: Despite wide applications of both mediation models and missing data techniques, formal discussion of mediation analysis with missing data is still rare. We introduce and compare four approaches to dealing with missing data in mediation analysis including listwise deletion, pairwise deletion, multiple imputation (MI), and a two-stage maximum likelihood (TS-ML) method. An R

package bmem is developed to implement the four methods for mediation analysis with missing data in the structural equation modeling framework, and two real examples are used to illustrate the application of the four methods. The four methods are evaluated and compared under MCAR, MAR, and MNAR missing data mechanisms through simulation studies. Both MI and TS-ML perform well for MCAR and MAR data regardless of the inclusion of auxiliary variables and for AV-MNAR data with auxiliary variables. Although listwise deletion and pairwise deletion have low power and large parameter estimation bias in many studied conditions, they may provide useful information for exploring missing mechanisms.

Zyphur et al.: From data to causes I: Building a general cross-lagged panel model (GCLM) **Zyphur-Allison-Tay-etal-2019**

Michael J. Zyphur, Paul D. Allison, et al. "From data to causes I: Building a general cross-lagged panel model (GCLM)". In: *Organizational Research Methods* 23.4 (May 2019), pp. 651–687. ISSN: 1552-7425. DOI: 10.1177/1094428119847278.

Abstract: This is the first paper in a series of two that synthesizes, compares, and extends methods for causal inference with longitudinal panel data in a structural equation modeling (SEM) framework. Starting with a cross-lagged approach, this paper builds a general cross-lagged panel model (GCLM) with parameters to account for stable factors while increasing the range of dynamic processes that can be modeled. We illustrate the GCLM by examining the relationship between national income and subjective well-being (SWB), showing how to examine hypotheses about short-run (via Granger-Sims tests) versus long-run effects (via impulse responses). When controlling for stable factors, we find no short-run or long-run effects among these variables, showing national SWB to be relatively stable, whereas income is less so. Our second paper addresses the differences between the GCLM and other methods. Online Supplementary Materials offer an Excel file automating GCLM input for Mplus (with an example also for Lavaan in R) and analyses using additional data sets and all program input/output. We also offer an introductory GCLM pre-

sentation at https://youtu.be/tHnnaRNPbXs. We conclude with a discussion of issues surrounding causal inference.

Zyphur et al.: From data to causes II: Comparing approaches to panel data analysis

Zyphur-Voelkle-Tay-etal-2019

Michael J. Zyphur, Manuel C. Voelkle, et al. "From data to causes II: Comparing approaches to panel data analysis". In: *Organizational Research Methods* 23.4 (May 2019), pp. 688–716. ISSN: 1552-7425. DOI: 10.1177/1094428119847280.

Abstract: This article compares a general cross-lagged model (GCLM) to other panel data methods based on their coherence with a causal logic and pragmatic concerns regarding modeled dynamics and hypothesis testing. We examine three "static" models that do not incorporate temporal dynamics: random- and fixed-effects models that estimate contemporaneous relationships; and latent curve models. We then describe "dynamic" models that incorporate temporal dynamics in the form of lagged effects: cross-lagged models estimated in a structural equation model (SEM) or multilevel model (MLM) framework; Arellano-Bond dynamic panel data methods; and autoregressive latent trajectory models. We describe the implications of overlooking temporal dynamics in static models and show how even popular cross-lagged models fail to control for stable factors over time. We also show that Arellano-Bond and autoregressive latent trajectory models have various shortcomings. By contrasting these approaches, we clarify the benefits and drawbacks of common methods for modeling panel data, including the GCLM approach we propose. We conclude with a discussion of issues regarding causal inference, including difficulties in separating different types of time-invariant and time-varying effects over time.