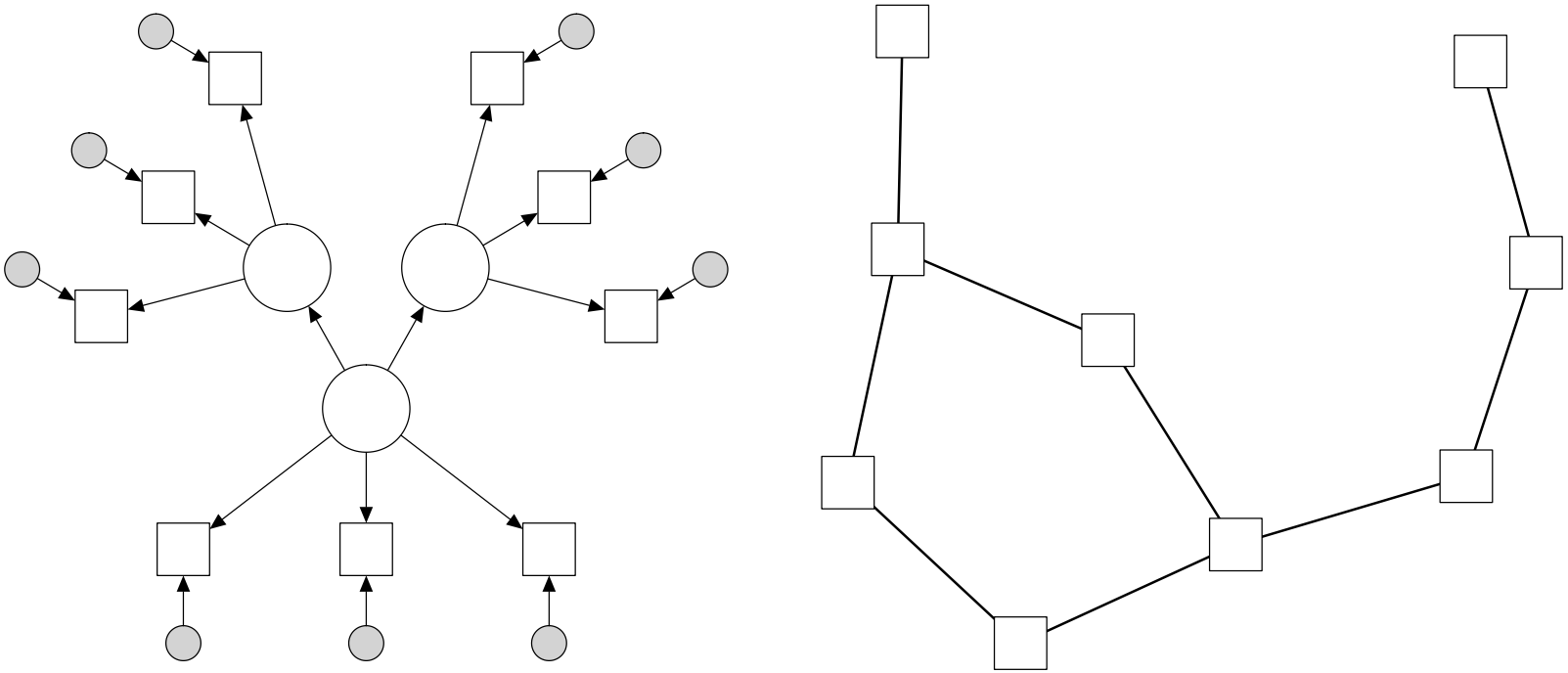
Intra-individual Networks and Latent Variable Models

APS 2018

Sacha Epskamp

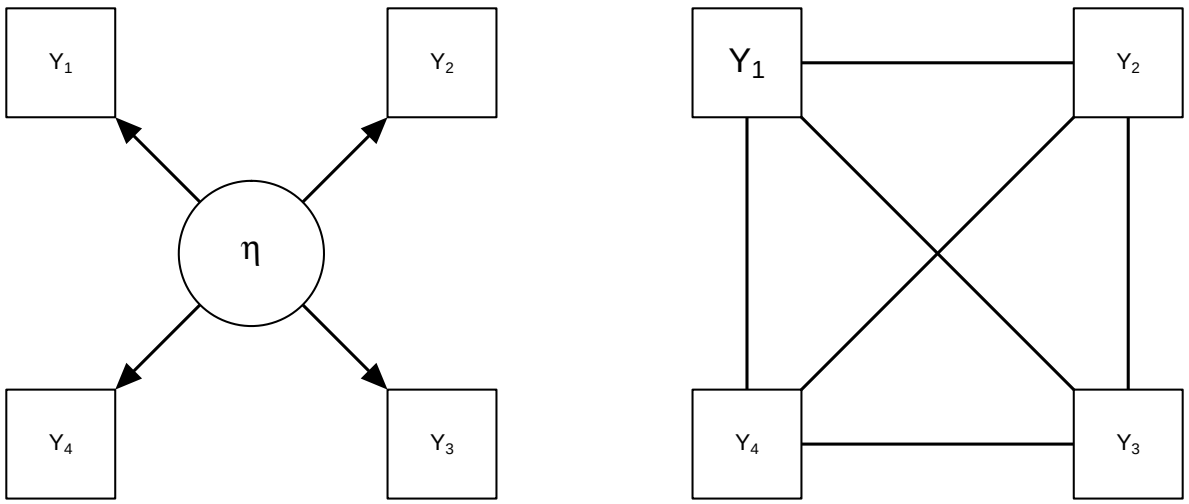
25-05-2018

Latent Variable Modeling and Network Modeling



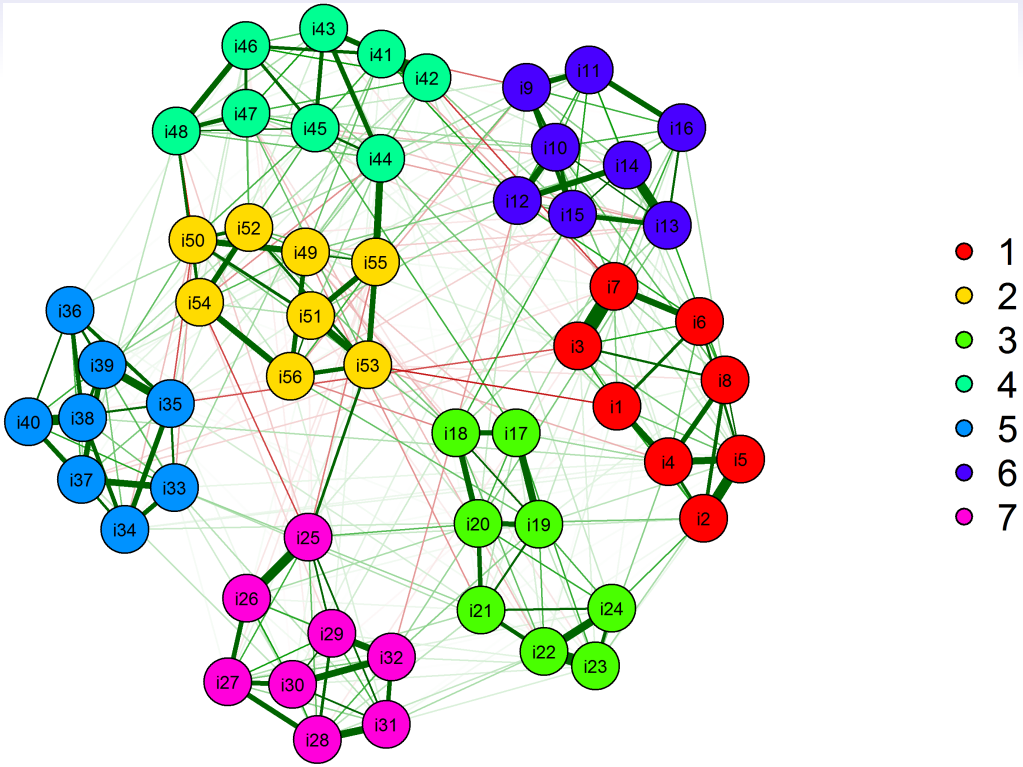
- How does one framework relate to the other?
- Can the frameworks be combined?
- Can you statistically compare between these frameworks?

Model Equivalence



Now well known for both network models for continuous data and network models for binary data: a unidimensional latent variable model is equivalent to a fully connected network.

- Marsman, M., Borsboom, D., Kruis, J., Epskamp, S., van Bork, R., Waldorp, L. J., van der Maas, H. L. J., & Maris, G. (2018). An introduction to network psychometrics: Relating ising network models to item response theory models. *Multivariate behavioral research, 53(1)*, 15-35.
- Golino, H. F., & Epskamp, S. (2017). Exploratory graph analysis: A new approach for estimating the number of dimensions in psychological research. *PloS one, 12(6)*, e0174035.



Fundamental rule of network psychometrics

Clusters in network = latent variables

- Golino, H. F., & Epskamp, S. (2017). Exploratory graph analysis: A new approach for estimating the number of dimensions in psychological research. *PloS one, 12(6)*, e0174035.

Consequences of Equivalence

- A single latent common cause leads to a fully connected network with only positive edges (after recoding reverse items)
- No statistical way to compare between these models
  - You can compare statistically between a *sparse* network and a latent variable model!
- Clusters in a network may be indicative of latent variables, or clusters in a network is what leads to latent variable models fitting!
- Estimating a network with many edges does not provide evidence against the latent variable model

PLOS | ONE

RESEARCH ARTICLE

Estimating psychopathological networks: Be careful what you wish for

Sacha Epskamp*, **Joost Kruis**, **Maarten Marsman**

Department of Psychological Methods, University of Amsterdam, Amsterdam, The Netherlands

* s.epskamp@uva.nl

OPEN ACCESS

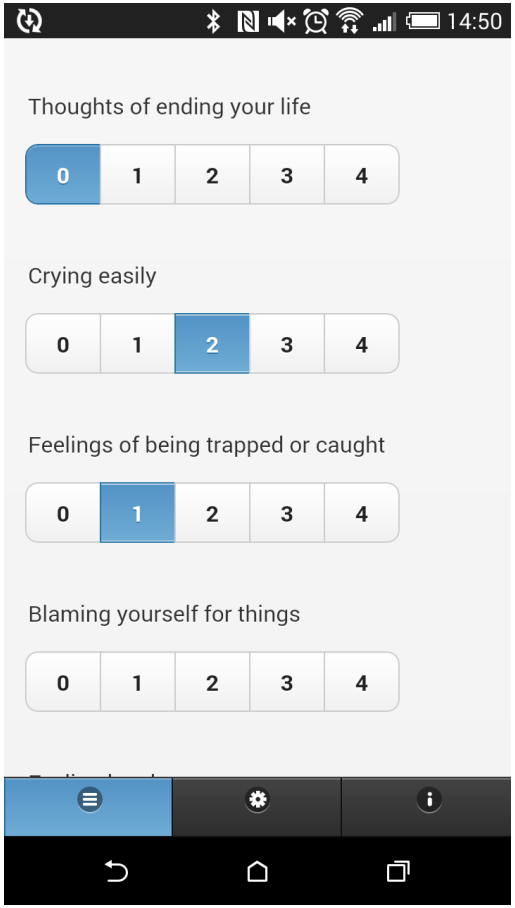
Citation: Epskamp S, Kruis J, Marsman M (2017) Estimating psychopathological networks: Be careful what you wish for. PLoS ONE 12(6): e0179891. https://doi.org/10.1371/journal.pone.0179891

Editor: Daniele Marinazzo, Ghent University, BELGIUM

Abstract

Network models, in which psychopathological disorders are conceptualized as a complex interplay of psychological and biological components, have become increasingly popular in the recent psychopathological literature (Borsboom, et. al., 2011). These network models often contain significant numbers of unknown parameters, yet the sample sizes available in psychological research are limited. As such, general assumptions about the true network are introduced to reduce the number of free parameters. Incorporating these assumptions, however, means that the resulting network will lead to reflect the particular structure assumed by the estimation method—a crucial and often ignored aspect of psychopathological networks. For example, observing a sparse structure and simultaneously assuming a sparse structure does not imply that the true model is, in fact, sparse. To illustrate this point, we discuss recent literature and show the effect of the assumption of sparsity in three simulation studies.

Time-series data



Subject	Time	Item 1	Item 2	Item 3
Subject 1	Time 1	2	2	4
Subject 1	Time 2	2	4	4
Subject 1	Time 3	1	4	3
Subject 2	Time 1	4	1	2
Subject 2	Time 2	3	1	2
Subject 2	Time 3	3	2	1
Subject 3	Time 1	1	3	0
Subject 3	Time 2	4	0	1
Subject 3	Time 3	0	3	3

- Arguments against estimating networks from cross-sectional data
  - Relationships may not generalize to within-person level
  - Relationships should unfold over time

Temporal effects

	relaxed	sad	nervous	concentration	tired	rumination	bodily.discomfort	time
31	5	6	4	5	6	4	4	2014-05-01 10:15:00
32	3	5	4	5	6	4	5	2014-05-01 13:15:00
33	NA	NA	NA	NA	NA	NA	NA	2014-05-01 16:15:00
34	3	5	4	5	6	4	4	2014-05-01 19:15:00
35	4	6	4	4	7	5	4	2014-05-01 22:15:00
36	4	3	3	5	5	2	3	2014-05-02 10:15:00
37	4	3	4	5	5	3	2	2014-05-02 13:15:00

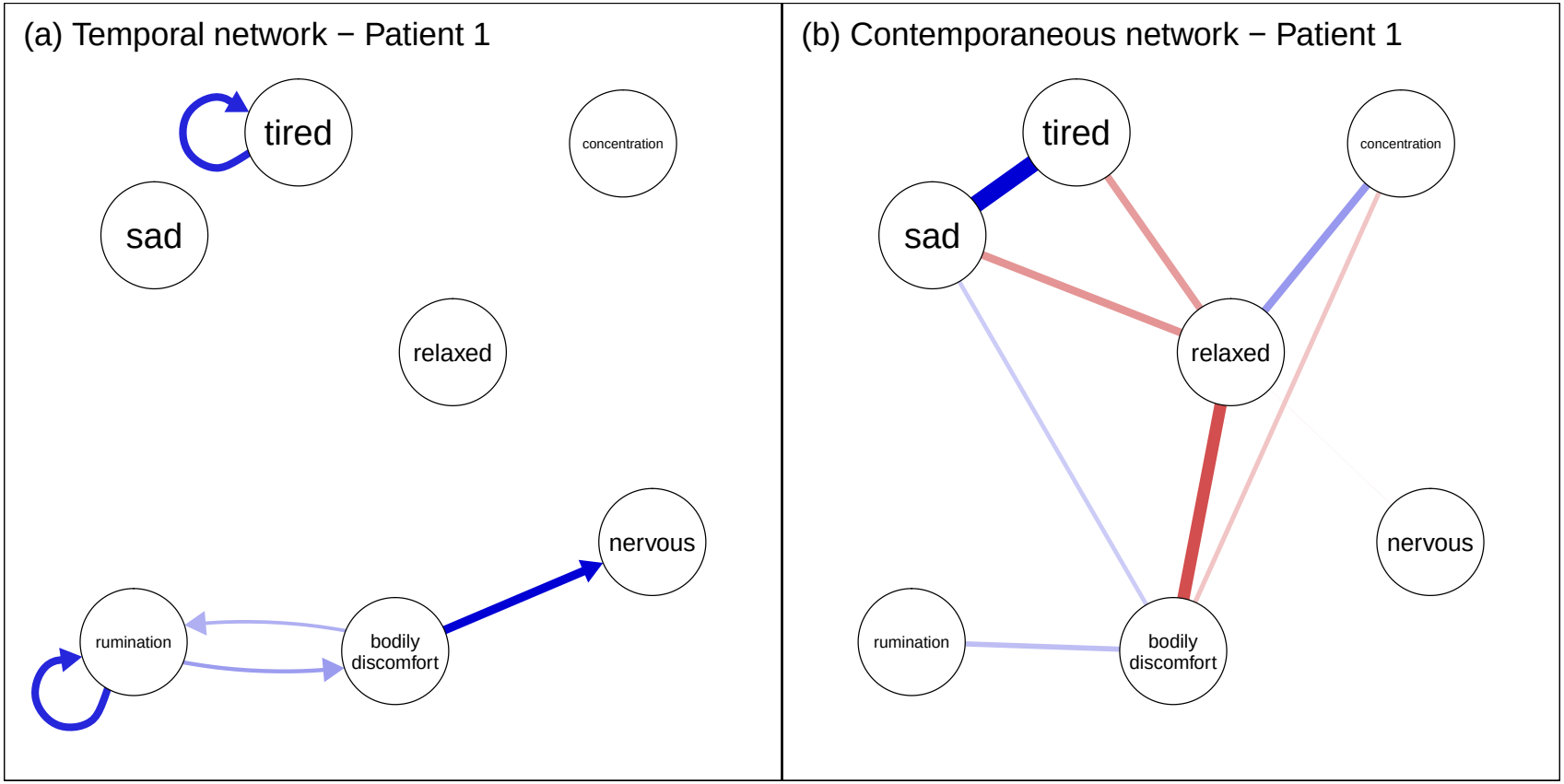
- The temporal network shows that one variable predicts another variable in the *next* measurement occasion
- *Granger causality*

Contemporaneous effects

	relaxed	sad	nervous	concentration	tired	rumination	bodily.discomfort	time
31	5	6	4	5	6	4	4	2014-05-01 10:15:00
32	3	5	4	5	6	4	5	2014-05-01 13:15:00
33	NA	NA	NA	NA	NA	NA	NA	2014-05-01 16:15:00
34	3	5	4	5	6	4	4	2014-05-01 19:15:00
35	4	6	4	4	7	5	4	2014-05-01 22:15:00
36	4	3	3	5	5	2	3	2014-05-02 10:15:00
37	4	3	4	5	5	3	2	2014-05-02 13:15:00

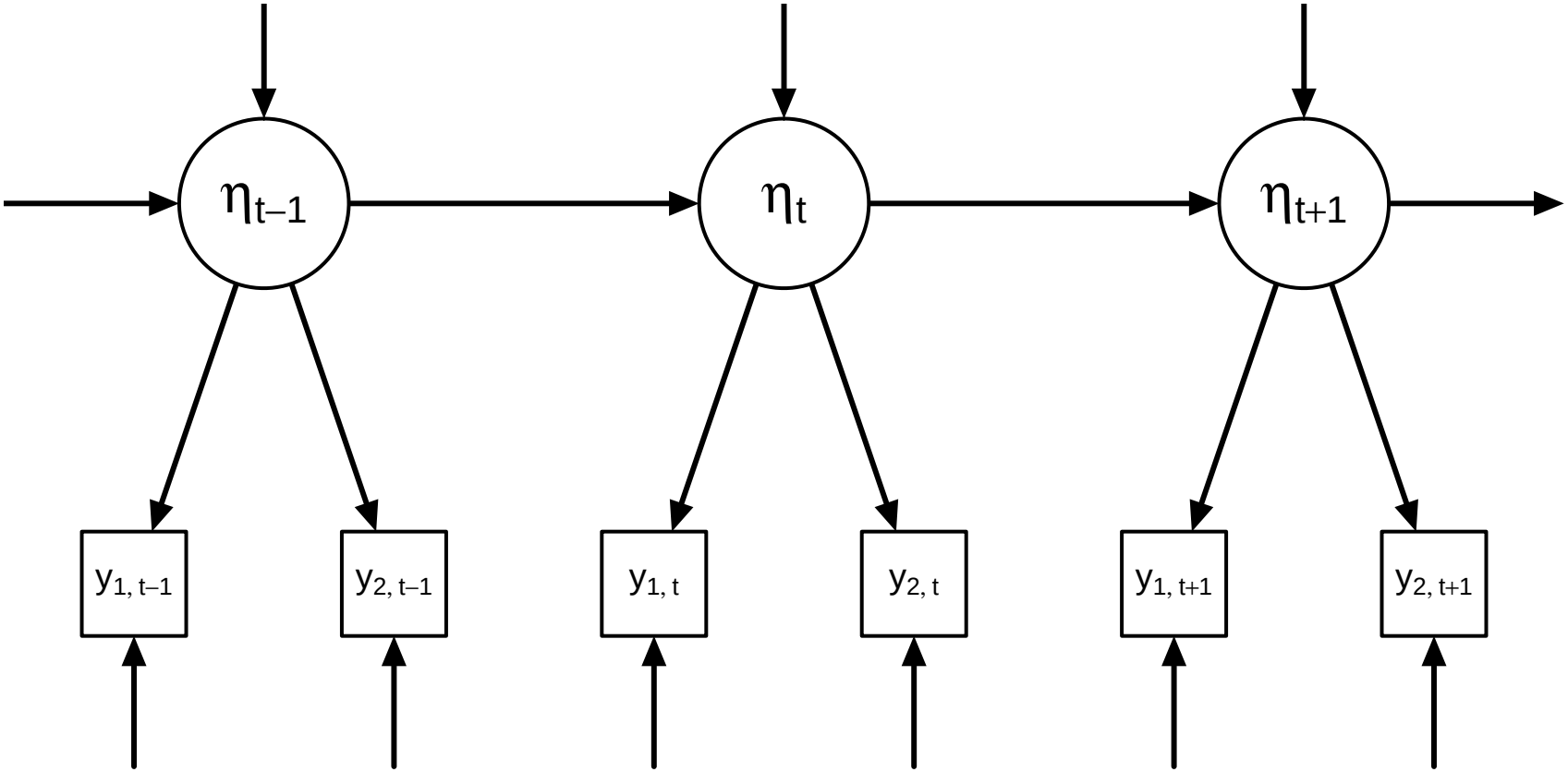
- The contemporaneous network shows that two variables predict one-another after taking temporal information into account
- Contains effects faster than the time-window of measurement
  - Somatic arousal $\rightarrow$ anticipation of panic attack $\rightarrow$ anxiety

Personalized Networks in Clinical Practice



- Contemporaneous network: conditional concentration given $t-1$
- Temporal network: regression coefficients between $t-1$ and t

What if data were caused by a dynamical factor model?



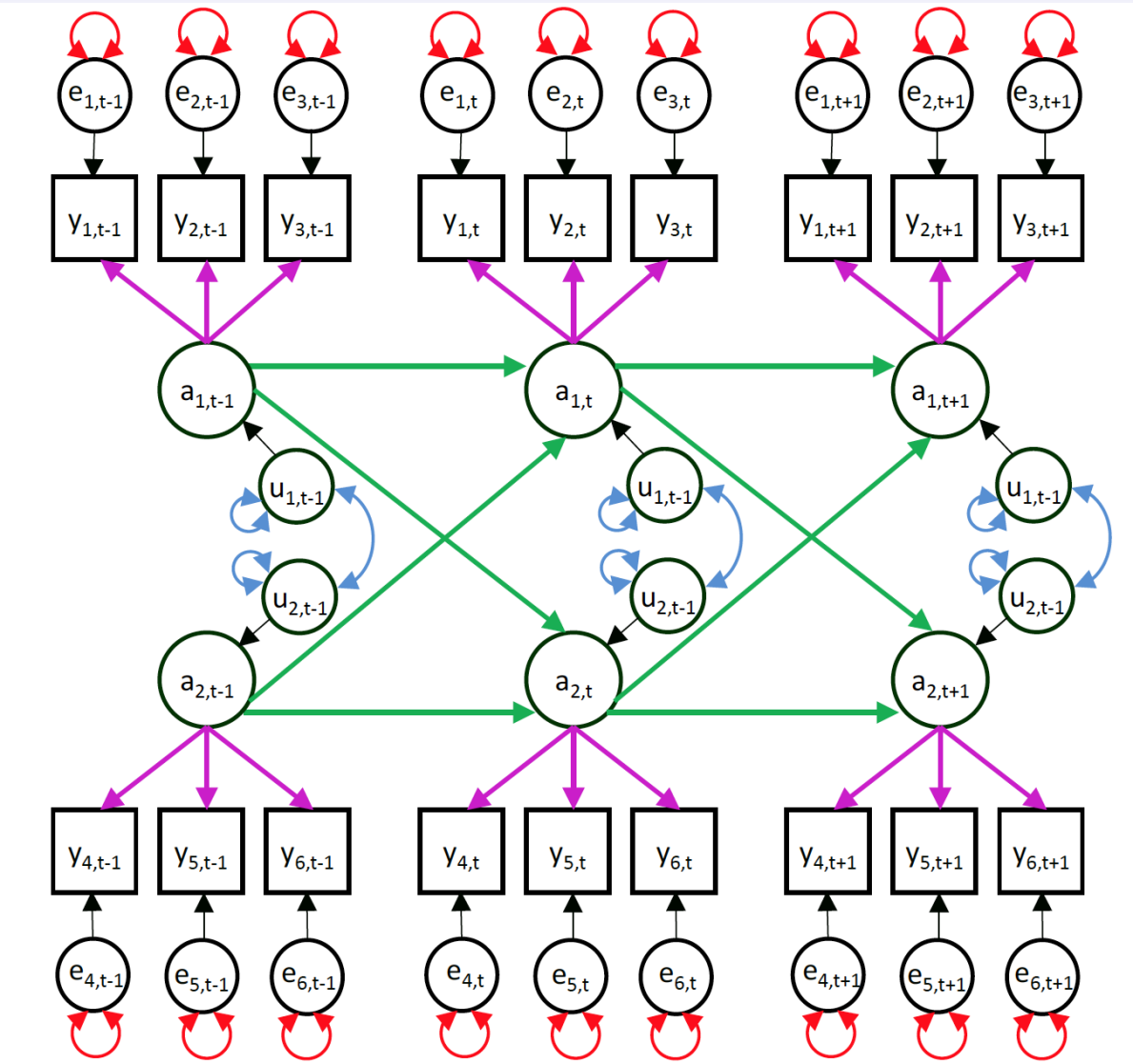
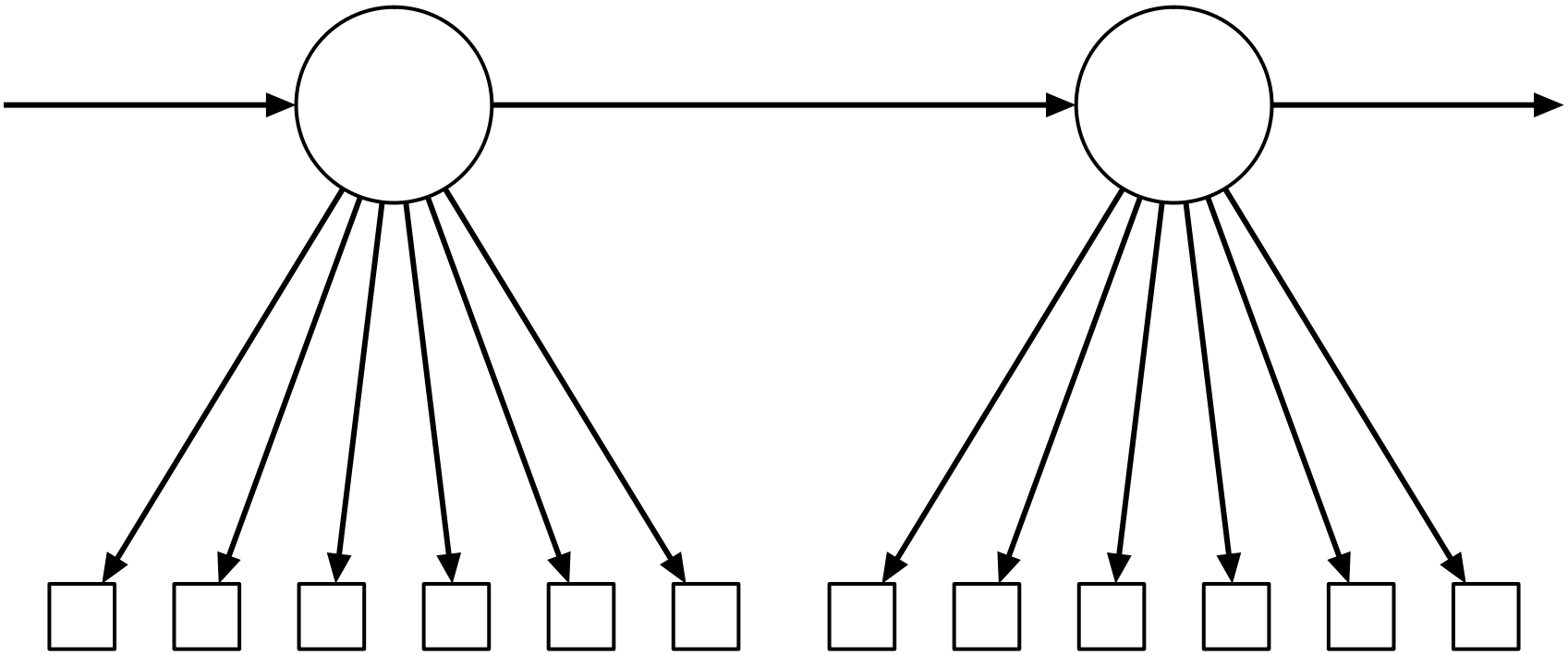


Figure by Ellen Hamaker.

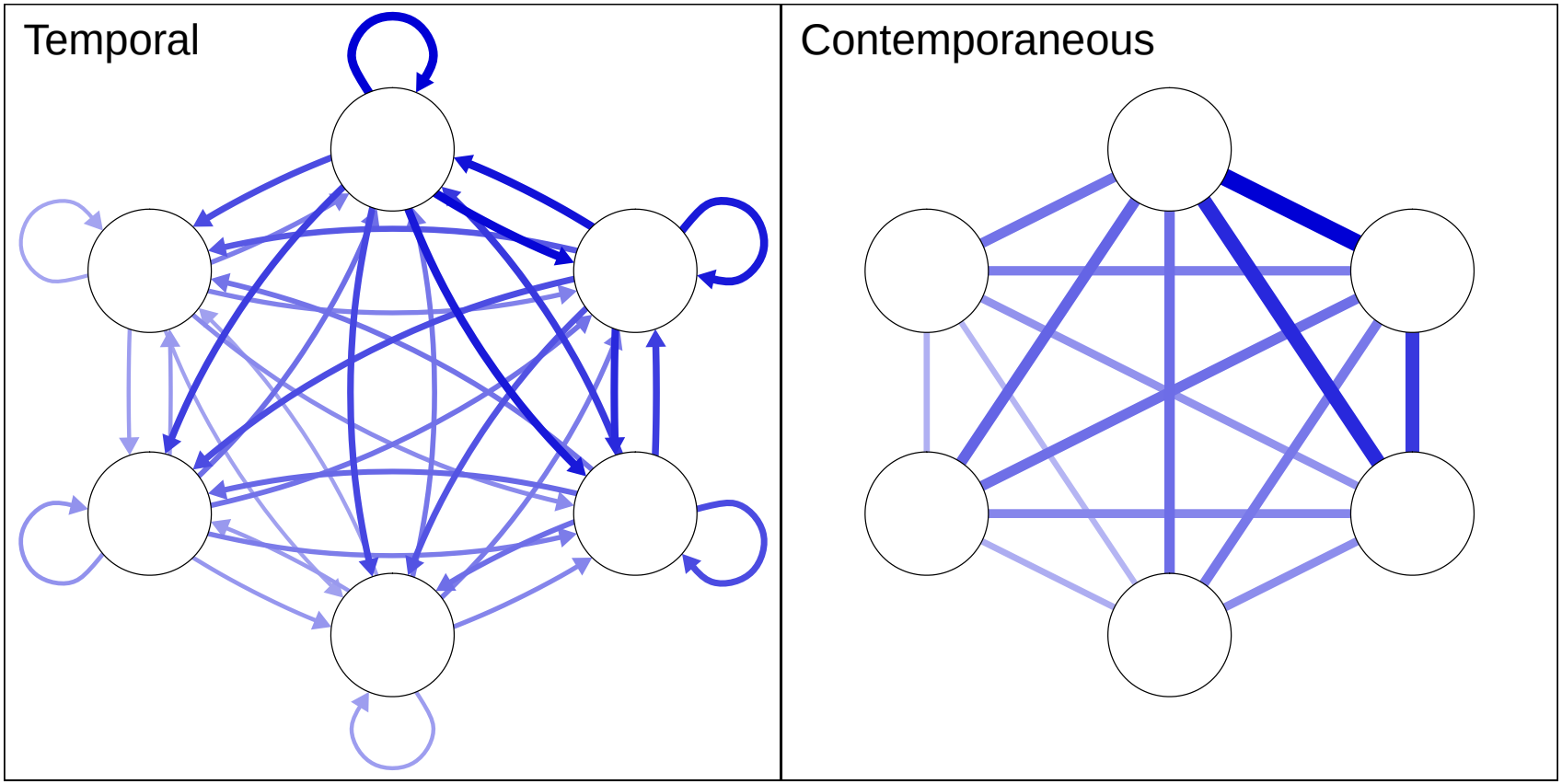
Example

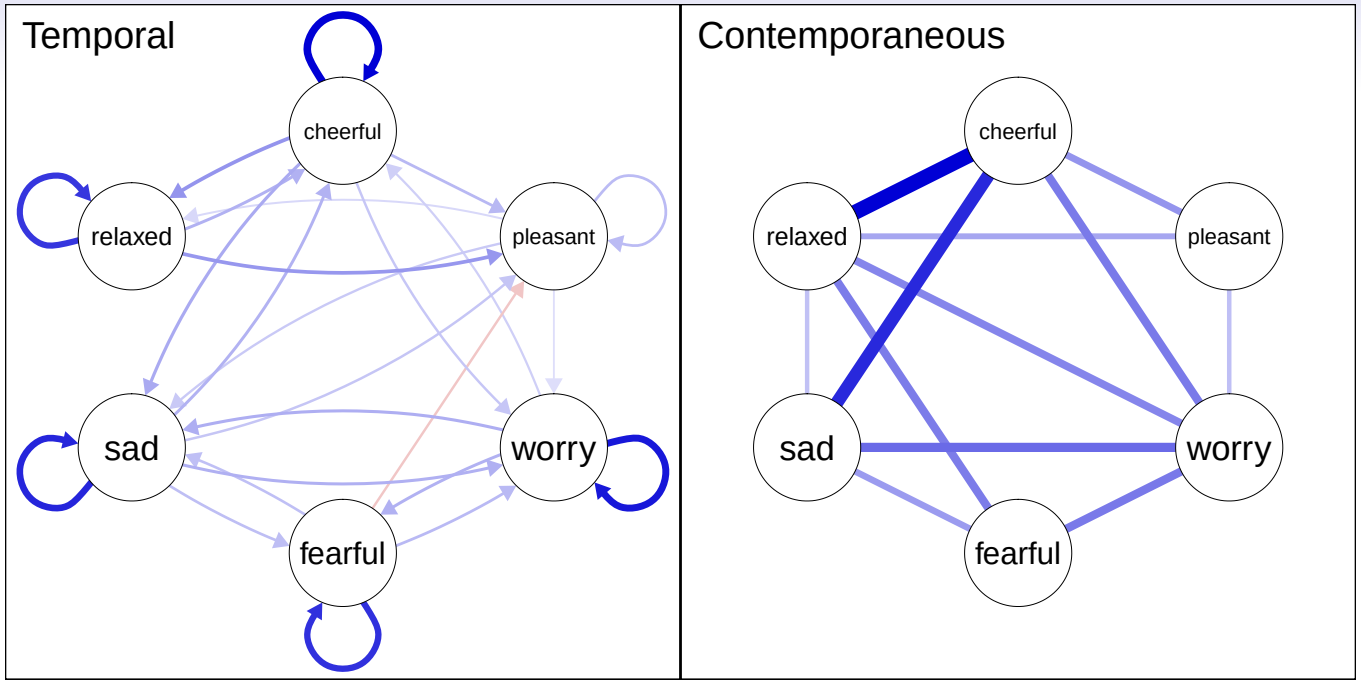


Example: all loadings $\sim U(0.5, 1)$, residual variances $\sim U(0.5, 1)$, autocorrelation $= 0.5$ and innovation variance $= 1$.

Model Equivalence

A dynamical factor model implies fully connected positive (after rescoring variables) contemporaneous and temporal networks!





Estimated using two-step multi-level VAR (mlVAR). Data from:

- Geschwind, N., Peeters, F., Drukker, M., van Os, J., & Wichers, M. (2011). Mindfulness training increases momentary positive emotions and reward experience in adults vulnerable to depression: a randomized controlled trial. *Journal of Consulting and Clinical Psychology, 79(5)*, 618–628.
- Bringmann, L. F., Vissers, N., Wichers, M., Geschwind, N., Kuppens, P., Peeters, F., Borsboom, D., & Tuerlinckx, F. (2013). A network approach to psychopathology: New insights into clinical longitudinal data. *PLOS ONE, 8(4)*, e60188.

On the equivalence between lag-1 dynamic factor modeling and graphical vector auto-regression

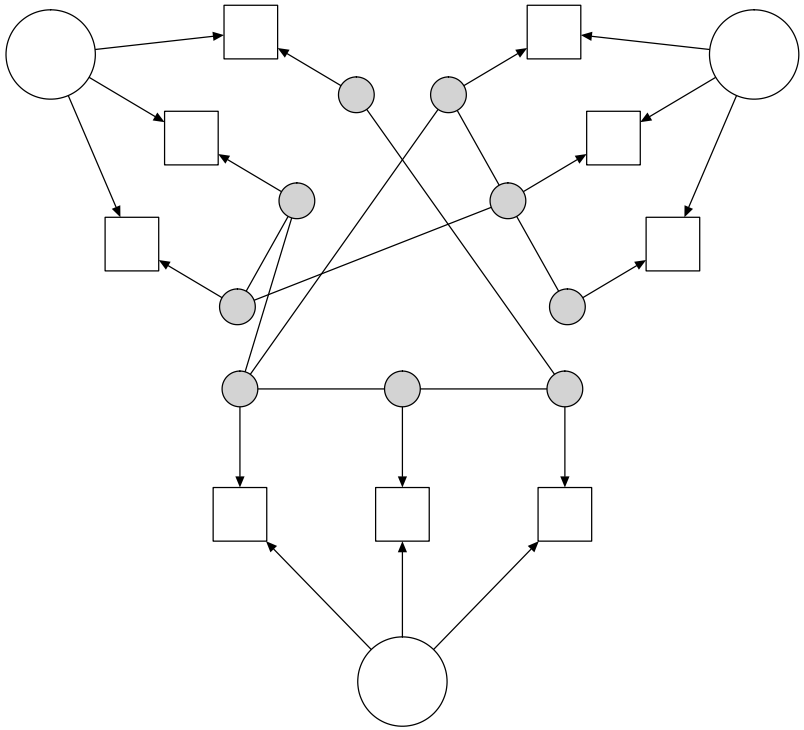
Sacha Epskamp & Riet van Bork

Work in progress...

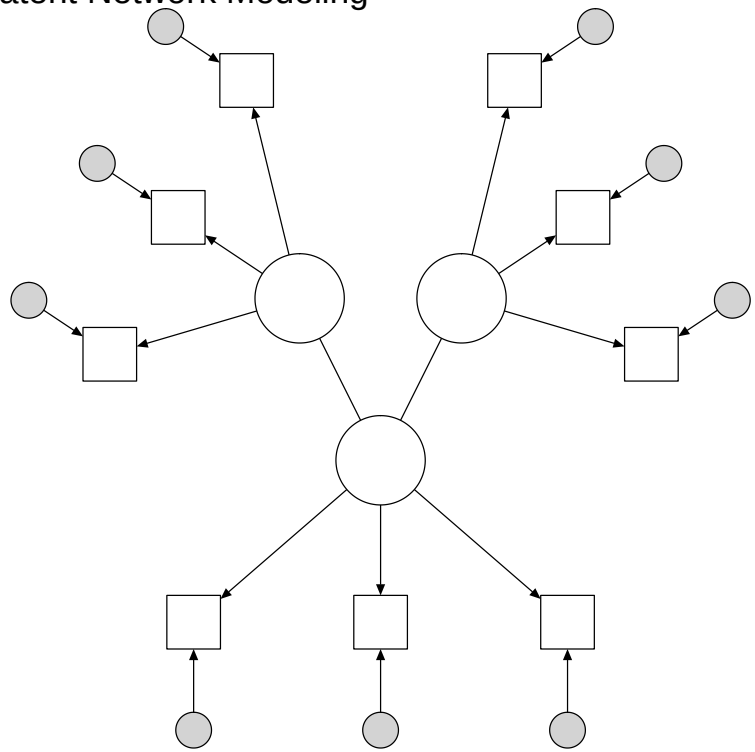
Generalized Network Psychometrics

Augment Structural Equation Models (SEM) by modeling either the residuals or latent covariances as a Gaussian Graphical model (GGM):

Residual Network Modeling

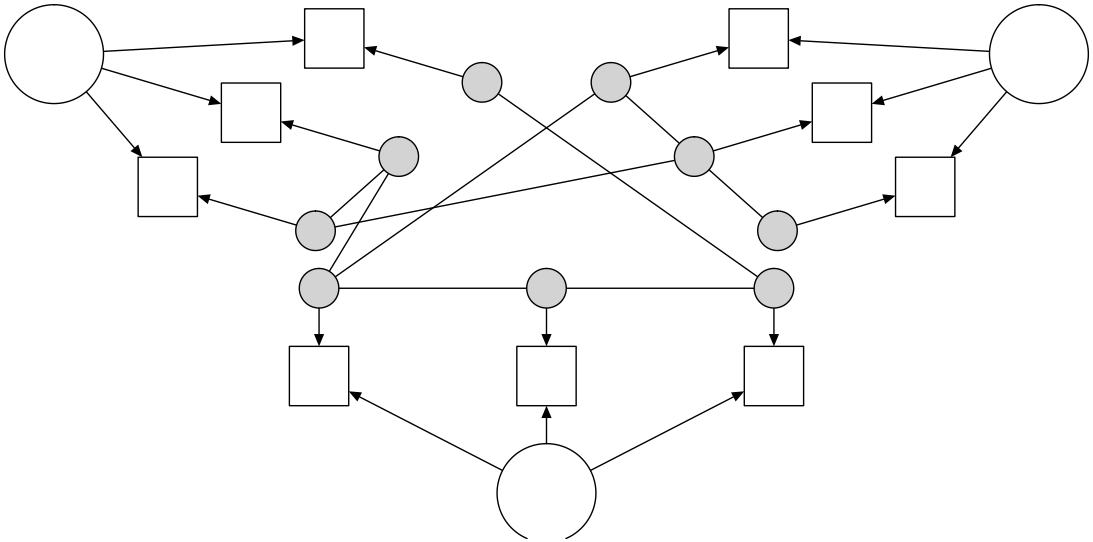


Latent Network Modeling



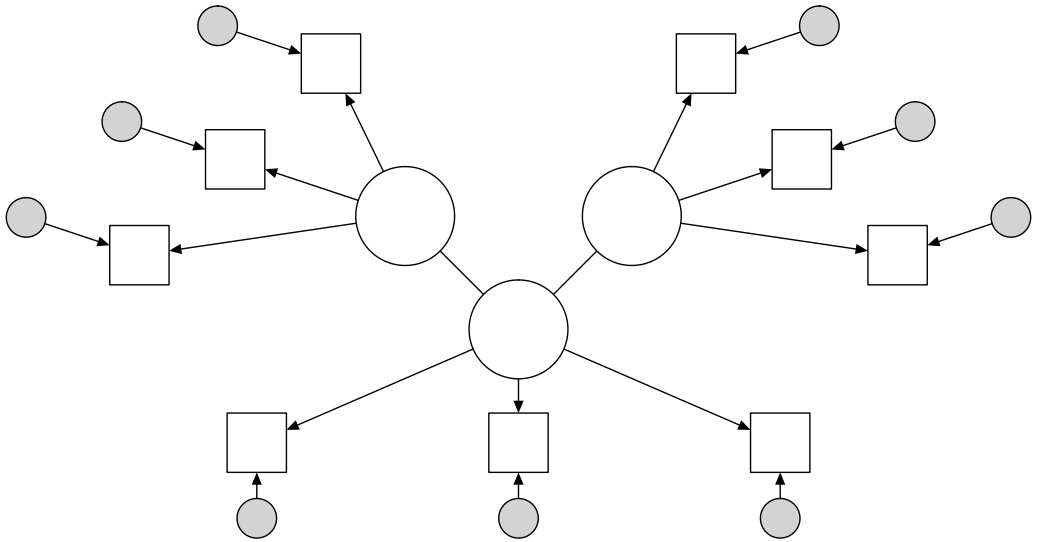
Residual Network Modeling (RNM)

- Network is formed at the residuals of SEM
- Model a network while not assuming no unobserved common causes
- Model a latent variable structure without the assumption of local independence



Latent Network Modeling (LNM)

- Models conditional independence relations between latent variables as a network
- Model networks between latent variables
- Exploratory search for conditional independence relationships between latents



Psychometrika
pp 1–24

Generalized Network Psychometrics: Combining Network and Latent Variable Models

Authors | Authors and affiliations

Sacha Epskamp, Mijke Rhemtulla, Denny Borsboom

Article

First Online: 13 March 2017

DOI: 10.1007/s11336-017-9557-x

Cite this article as:
Epskamp, S., Rhemtulla, M. & Borsboom, D. Psychometrika (2017). doi:10.1007/s11336-017-9557-x

Conclusion

- While network models originated as alternative to latent variable modeling, the two frameworks are closely related
  - A unidimensional latent variable model is equivalent to a fully connected network
- This is also true for intra-individual VAR networks
  - An edge in the temporal network can easily occur due to a auto-correlated latent common cause
- Network models and latent variable models can also be combined
  - Residual network modeling
  - Latent network modeling

Thank you for your attention!