RECENT APPLICATIONS OF PSYCHOMETRIC NETWORK ANALYSIS

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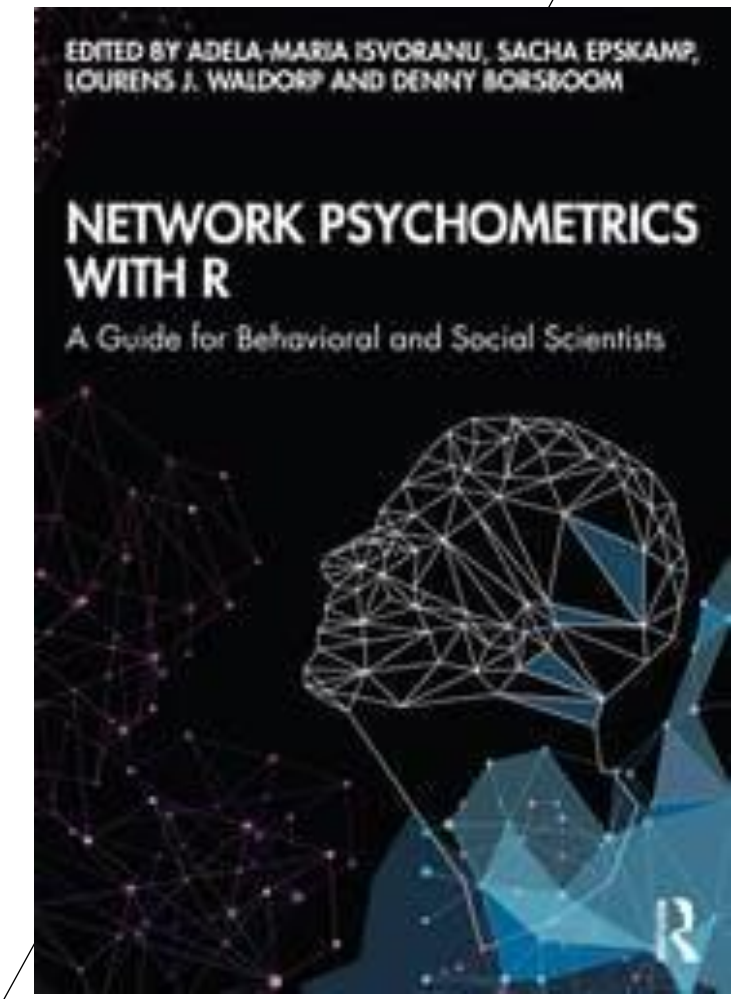
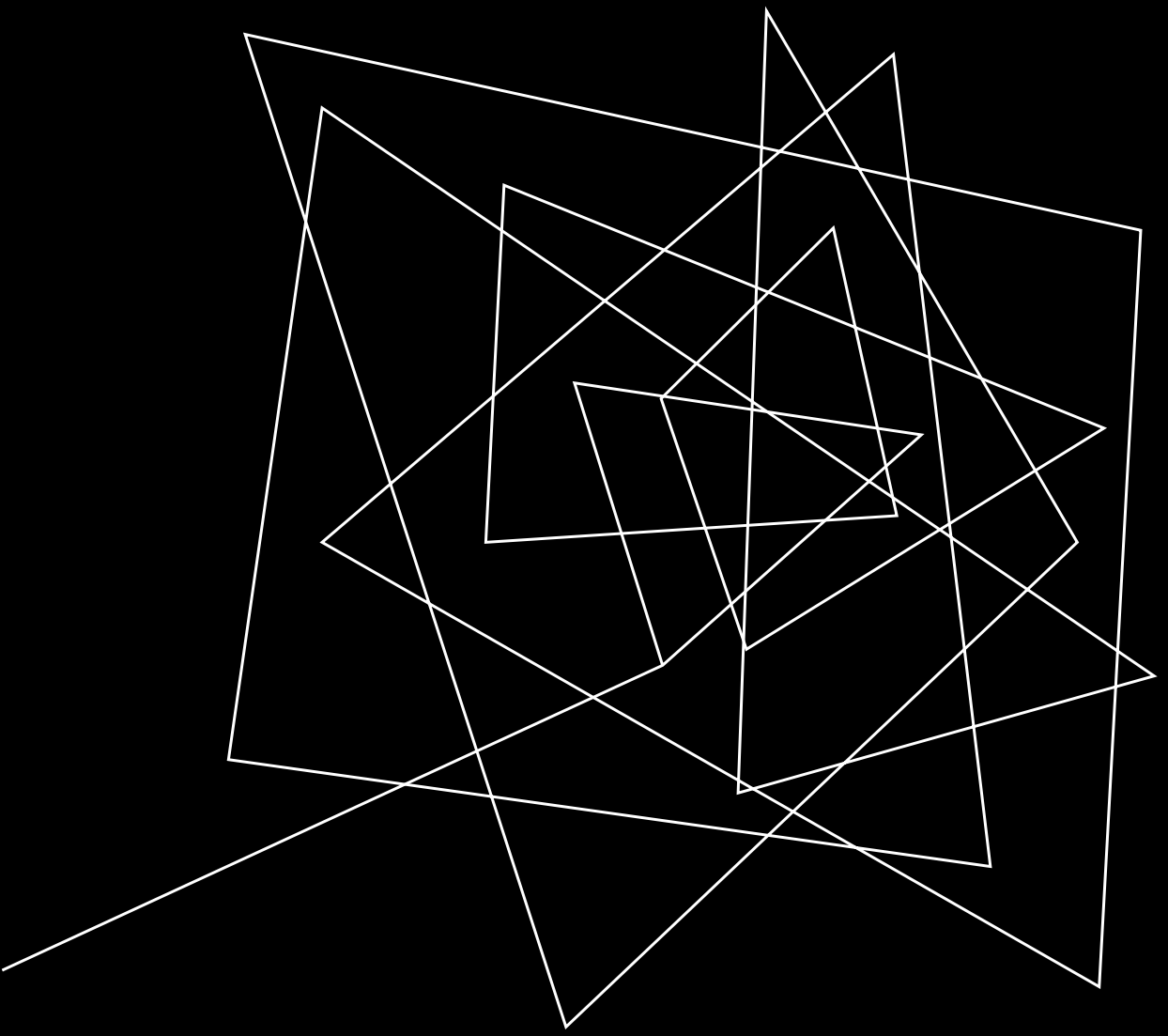
THE NETWORK PSYCHOMETRICS BIBLE

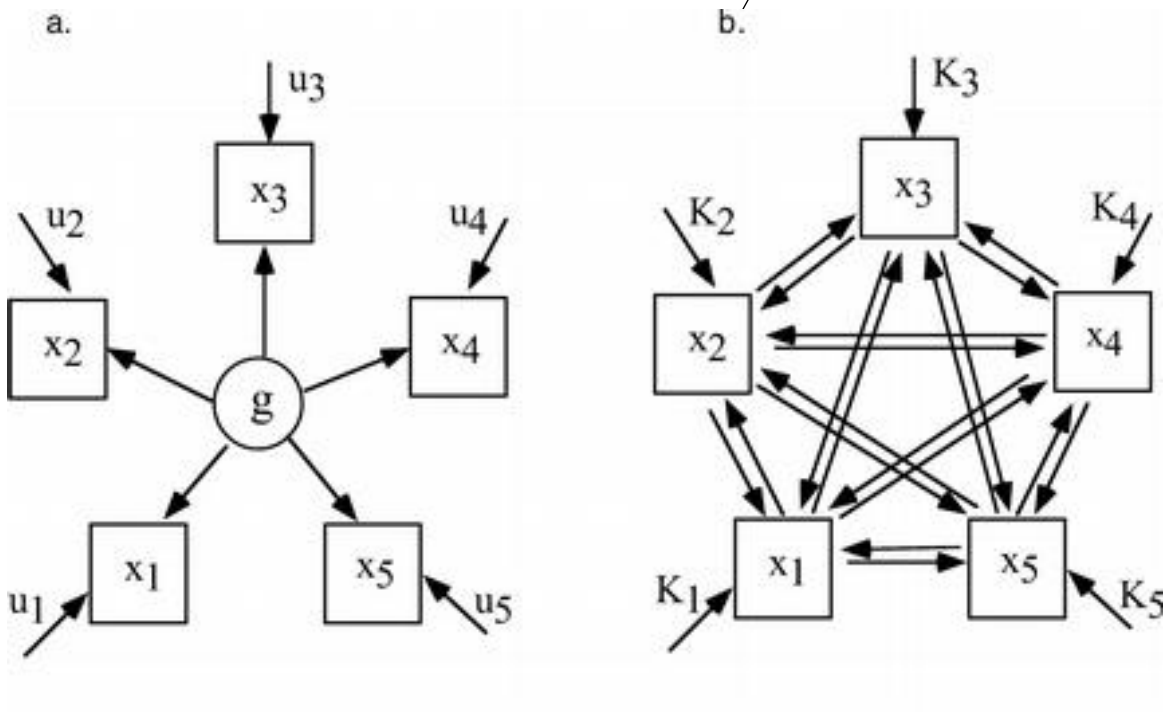




A (VERY SHORT) INTRODUCTION

WHY NETWORKS?

- An *alternative* to latent variable model: *emergent order* versus common causes
- Psychological constructs (intelligence, psychopathology, etc.) are *systems*
- These systems consist of entities (cognitive abilities, symptoms, etc.) that *interact:* reciprocal interaction and feedback
- Studying these *interactions* is the key to undestand psychological processes



Van Der Maas, H. L. J., Dolan, C. V., Grasman, R. P. P. P., Wicherts, J. M., Huizenga, H. M., & Raijmakers, M. E. J. (2006). A dynamical model of general intelligence: The positive manifold of intelligence by mutualism. *Psychological Review*, *113*(4), 842–861. https://doi.org/10.1037/0033-295X.113.4.842

THE MULTIVARIATE NETWORK FRAMEWORK AS A GRAPHICAL MODEL

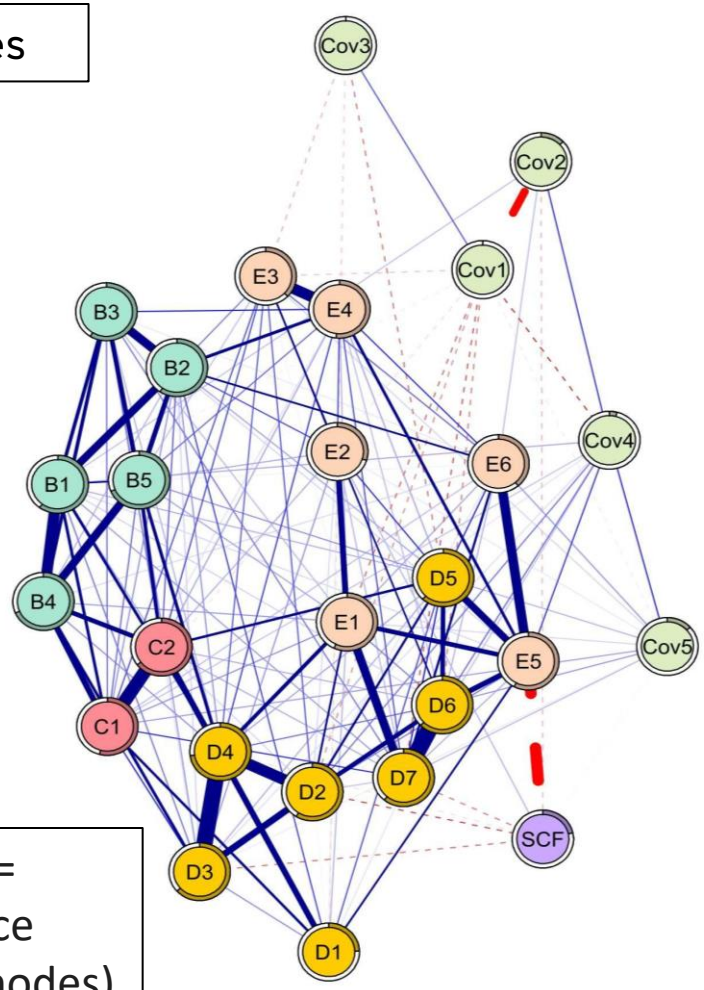
nodes = variables

edges = conditional associations

blue = positive, red = negative edge weights

thickness and brightness of an edge = association strength

rings around nodes = predictability (variance explained by connected nodes)



Covariates
- Cov1: Age
- Cov2: Sex
- Cov3: Level of education
- Cov4: Lifetime depression
- Cov5: Lifetime alcohol use disorder

Intrusions
- B1: Intrusive thoughts
- B2: Nightmares
- B3: Flashbacks
- B4: Emotional cue reactivity
- B5: Physiological cue reactivity

Avoidance
- C1: Avoidance of thoughts
- C2: Avoidance of reminders

Cognition & mood alterations
- D1: Trauma−related amnesia
- D2: Negative beliefs
- D3: Blame of self or others
- D4: Negative trauma−related emotions
- D5: Loss of interest
- D6: Detachment
- D7: Restricted affect

Arousal & reactivity alterations
- E1: Irritability/anger
- E2: Self−destructive/reckless behavior
- E3: Hypervigilance
- E4: Exaggerated startle response
- E5: Difficulty concentrating
- E6: Sleep disturbance

Subjective cognitive functioning
- SCF: Subjective cognitive functioning

Günak, M. M., Ebrahimi, O. V., Pietrzak, R. H., & Fried, E. I. (2023). Using network models to explore the associations between posttraumatic stress disorder symptoms and subjective cognitive functioning. *Journal of Anxiety Disorders*, *99*, 102768. https://doi.org/10.1016/j.janxdis.2023.102768

PAIRWISE MARKOV RANDOM FIELD ESTIMATION METHODS

1. Models for different variable distributions:

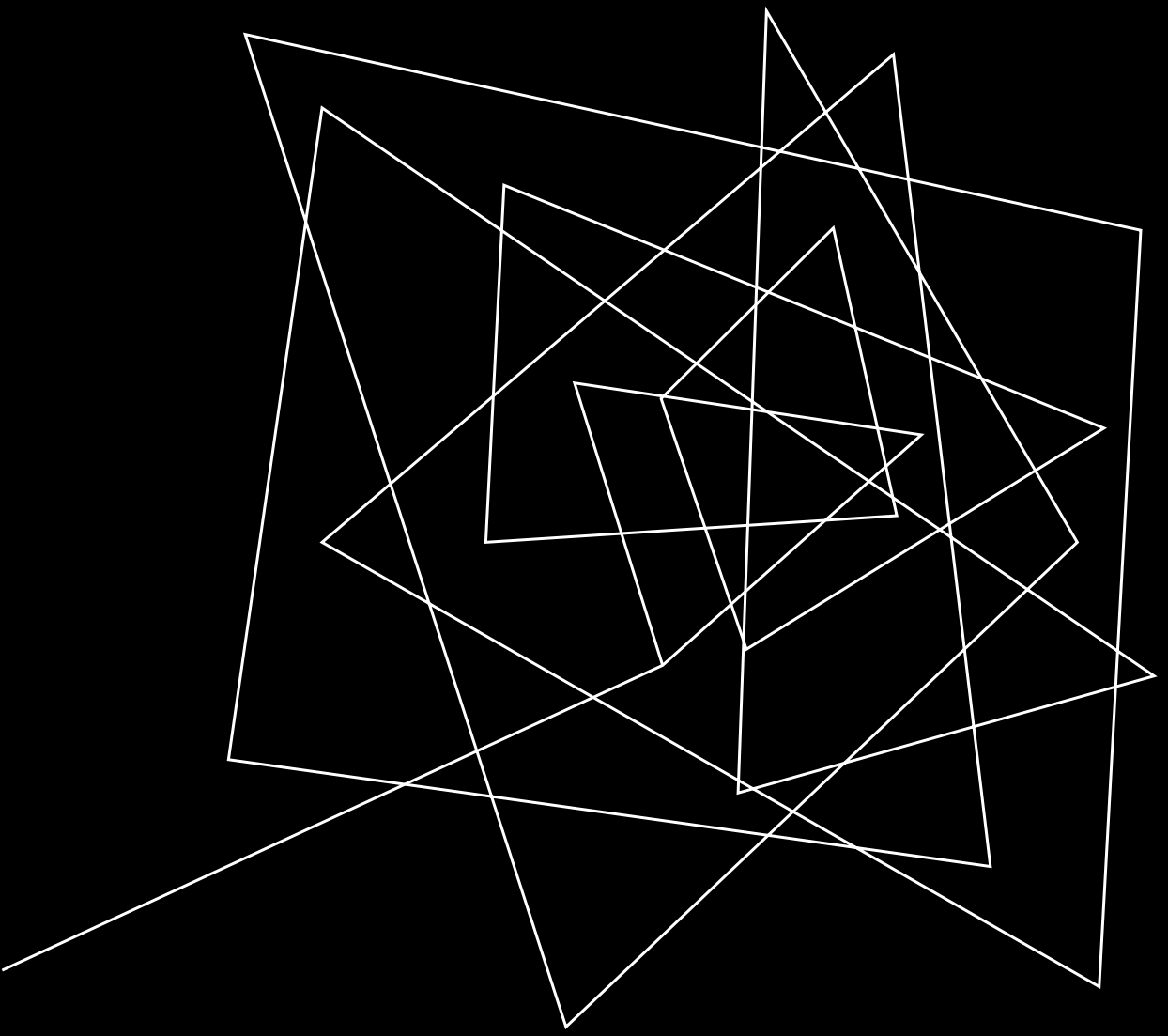
- Multivariate normal data: Gaussian Graphical Model (GGM)
- Binary data: Ising Model
- Combinations of Gaussian (normal), binary, nominal categorical, and Poisson (count) distributions: Mixed Graphical Model (MGM)

2. Methods for getting edge weight estimates:

- Joint estimation
- Nodewise estimation

3. Methods for deciding which edges to keep:

- *l*1 ("lasso") regularization
- thresholding (e.g., using p values)
- nonregularized model selection

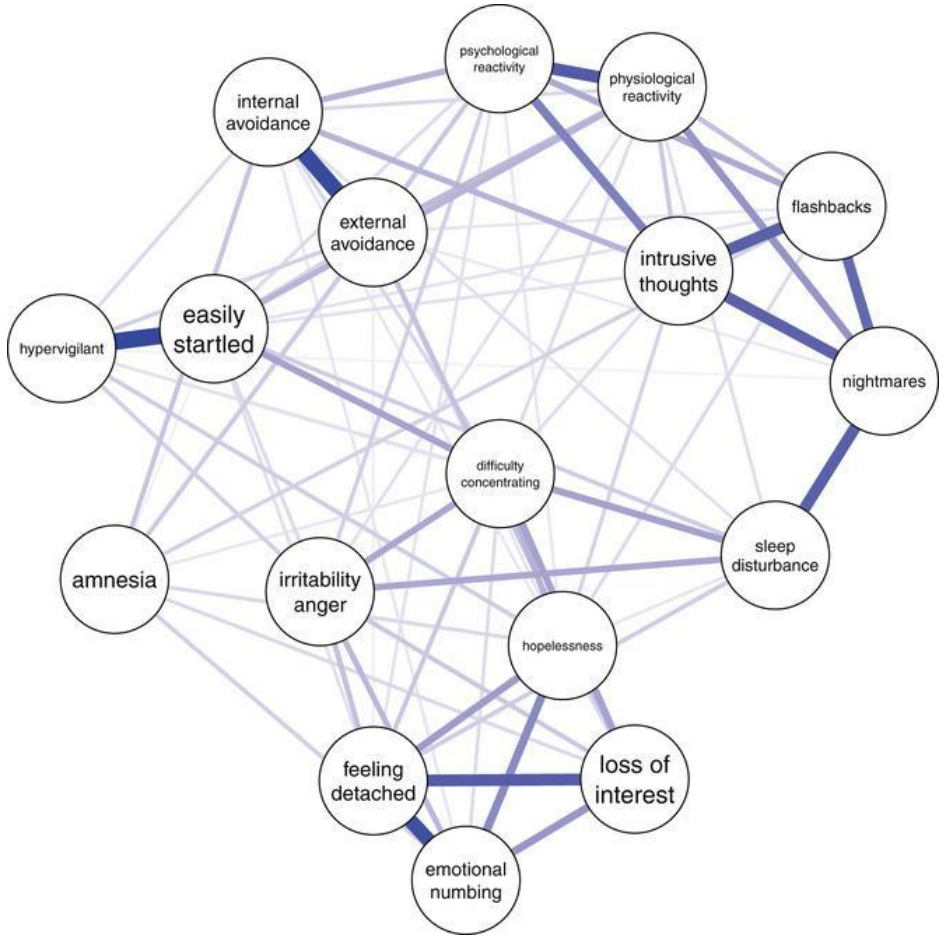


MODELS FOR DIFFERENT VARIABLE DISTRIBUTIONS

*DISCLAIMER:
BE CAREFUL, AS, THROUGHOUT THE PRESENTATION, I'M CITING SOME PREPRINTS THAT COULD BE NOT ACCEPTED FOR PUBLICATION YET

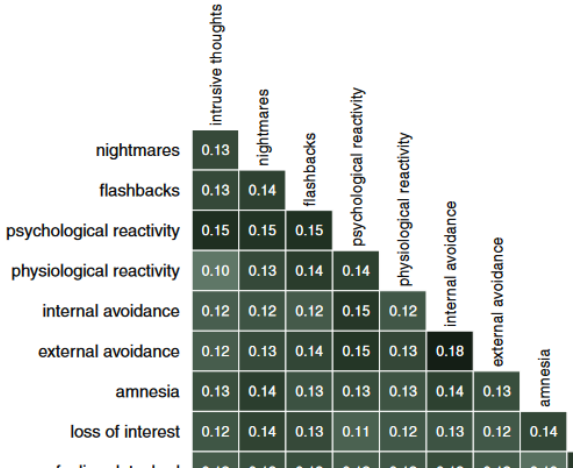
GGM AND META-ANALYTIC GAUSSIAN NETWORK AGGREGATION (MAGNA)

Estimated Pooled MAGNA Network on PTSD Symptoms



Estimations:

- Parameter estimates for the pooled MAGNA network -> ***edge weights*** and ***centrality*** estimates.
- Estimated parameter variance-covariance matrix (Fisher information) -> ***significance*** of edges, differences in ***centrality indices***.
- Standard deviations of random effects -> ***heterogeneity*** across studies

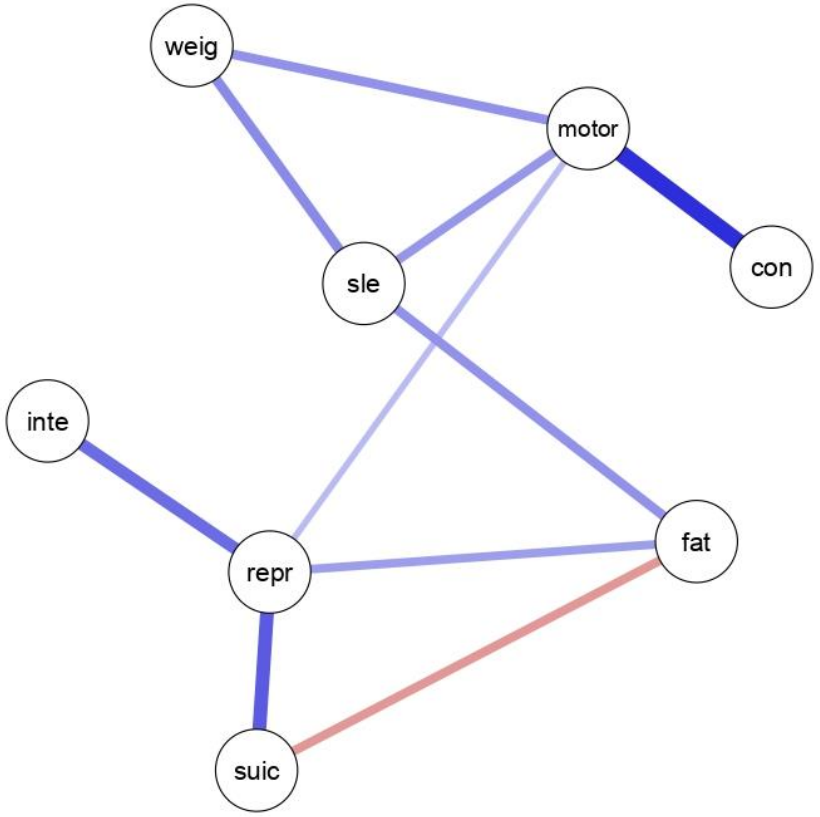


Isvoranu, A.-M., Epskamp, S., Cheung, M. W.-L. (2021). Network models of posttraumatic stress disorder: A meta-analysis. *Journal of Abnormal Psychology*, *130*(8), 841–861. https://doi.org/10.1037/abn0000704

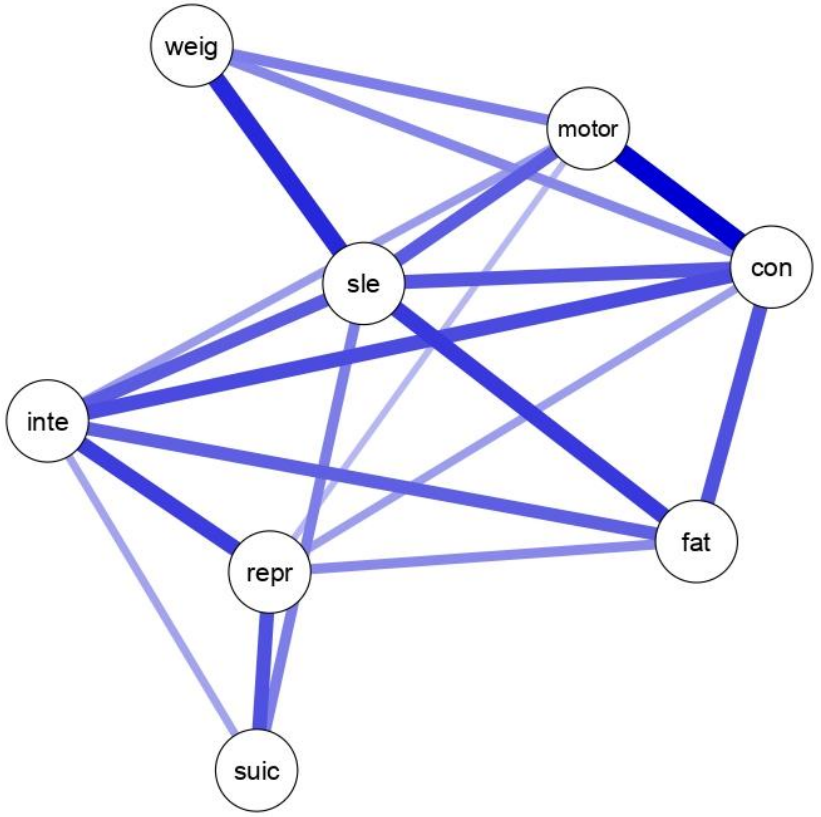
PSYCHOPATHOLOGY, ISING MODEL, AND SELECTION BIAS

Symptoms of Major Depressive Episode

Uncorrected IsingSampler



Corrected IsingSampler



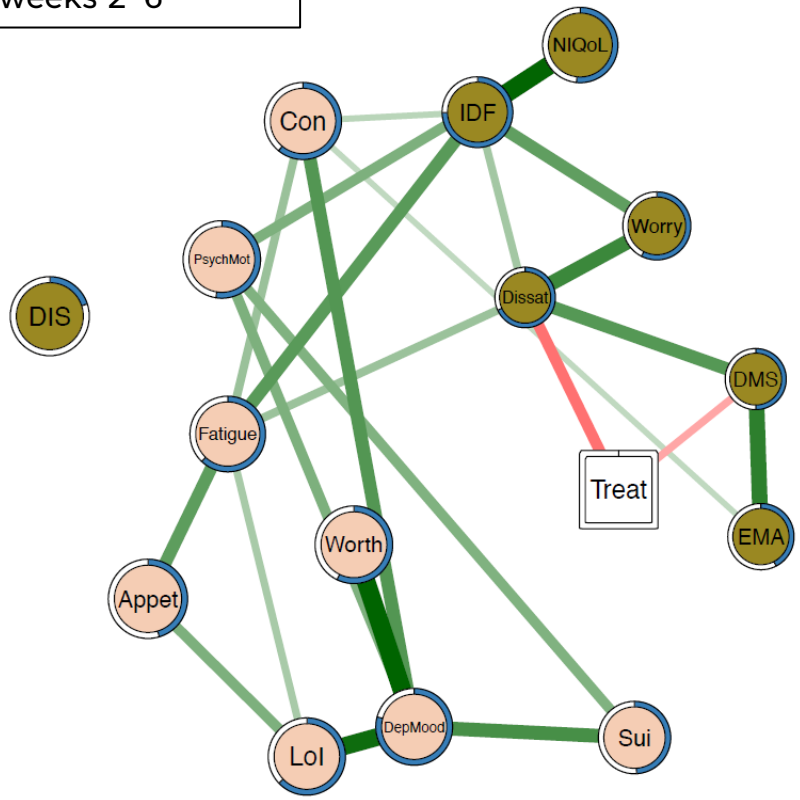
All symptoms are coded as binary variables (severe/not severe):

inte - loss of interest
weig - weight problems
sle- sleep problems
moto - psychomotor problems
fat – fatigue
repr - self-reproach *con* - concentration *suic* - suicidal ideation

Boot, J., Ron, J. de, Haslbeck, J., & Epskamp, S. (2023). *Correcting for selection bias after conditioning on a sum-score in the Ising model*. OSF Preprints. https://doi.org/10.31219/osf.io/xq8ur

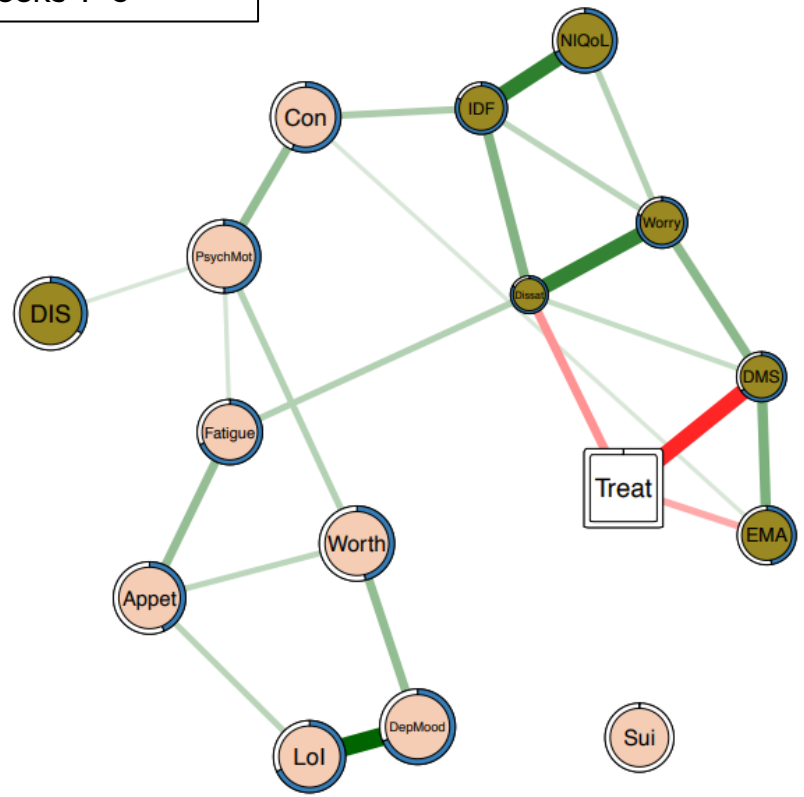
MIXED GRAPHICAL MODELS: NETWORK INTERVENTION ANALYSIS FOR TREATMENT EFFECTS EVALUATION

Treatment, weeks 2-6



Treatment has a direct negative effect on difficulty maintaining sleep and dissatisfaction with sleep.

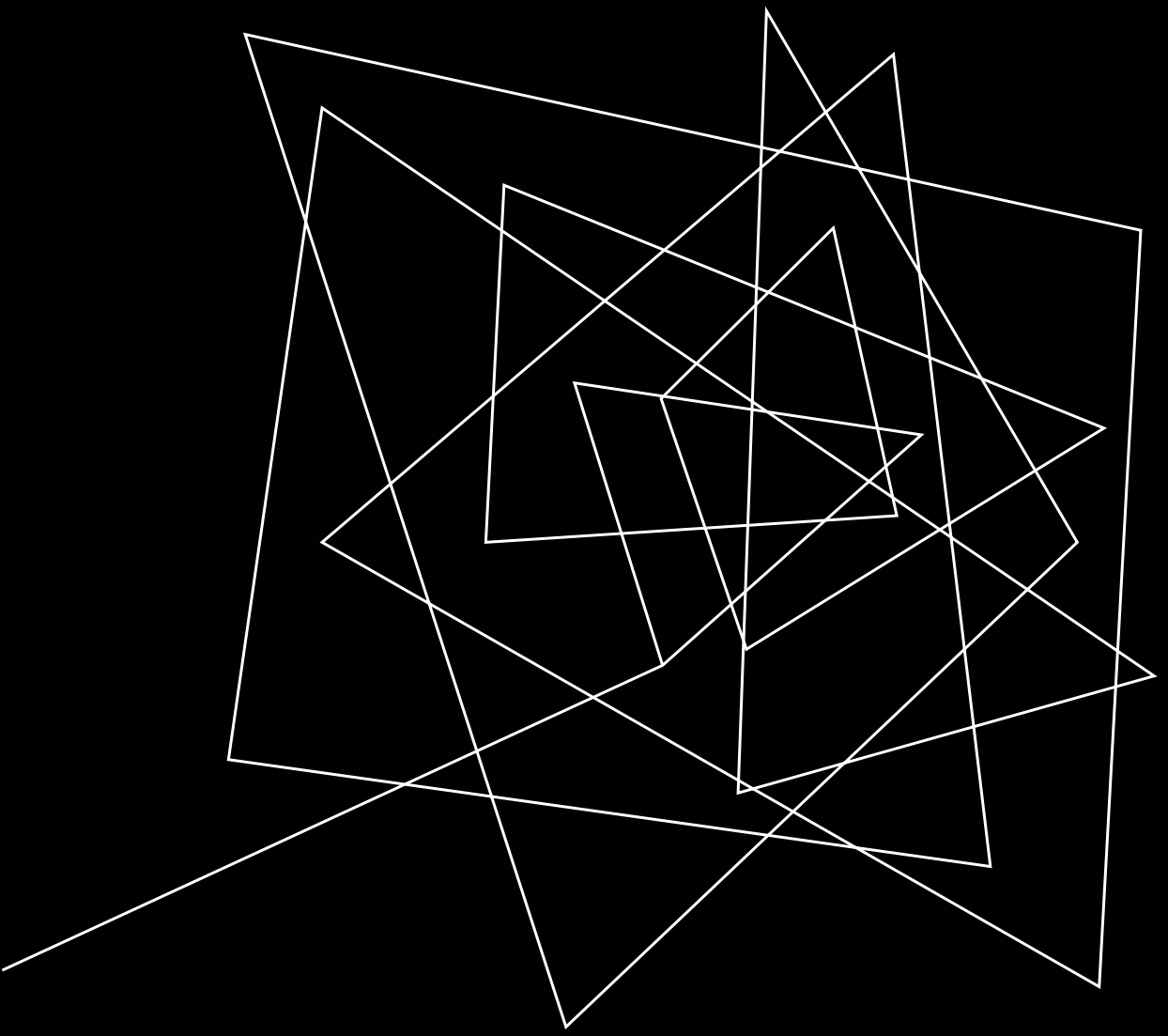
Post-treatment, weeks 7-9



Treatment has a direct negative effect on difficulty maintaining sleep, dissatisfaction with sleep and early morning awakening.

Sequential process of symptom-specific direct and indirect effects of treatment of co-occurring insomnia and depression

Blanken, T. F., Van Der Zweerde, T., Van Straten, A., Van Someren, E. J. W., Borsboom, D., & Lancee, J. (2019). Introducing Network Intervention Analysis to Investigate Sequential, Symptom-Specific Treatment Effects: A Demonstration in Co-Occurring Insomnia and Depression. *Psychotherapy and Psychosomatics*, *88*(1), 52–54. https://doi.org/10.1159/000495045

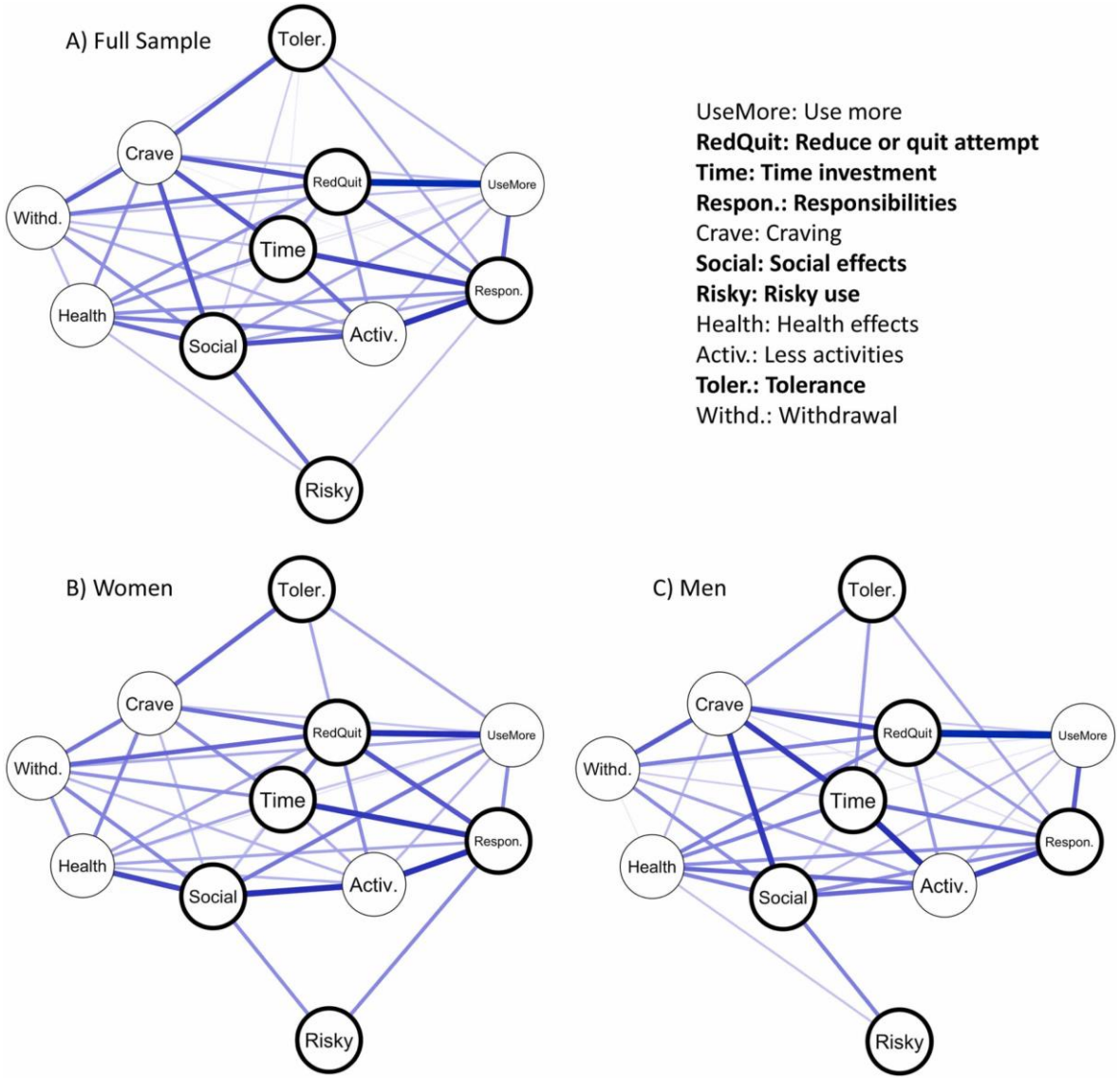


NETWORKS IN DIFFERENT DATA ENVIRONMENTS

CROSS-SECTIONAL AND LONGITUDINAL NETWORKS

1. **Cross-Sectional Network (single time point)**
   - Network represents a mix of between-and within-person associations
2. **Graphical Vector Auto-regressive (GVAR) Model**
   - Network for a time series from a single individual person (50+ time points)
   - Produces 2 networks: temporal and contemporaneous
3. **Multilevel GVAR Model**
   - Network for a sample of people, each of whom has many time points
   - Produces 3 networks: temporal, contemporaneous, and between-subjects
   - Assumes a shared network structure across people, with random individual deviations in edge weights
4. **GIMME (Group Iterative Multiple Model Estimation)**
   - Individual networks are estimated and summarized, bottom-up, into a group structure
5. **Panel Model**
   - Network for a sample of people, each of whom has few time points

CROSS-SECTIONAL NETWORKS AND NETWORK COMPARISON TEST



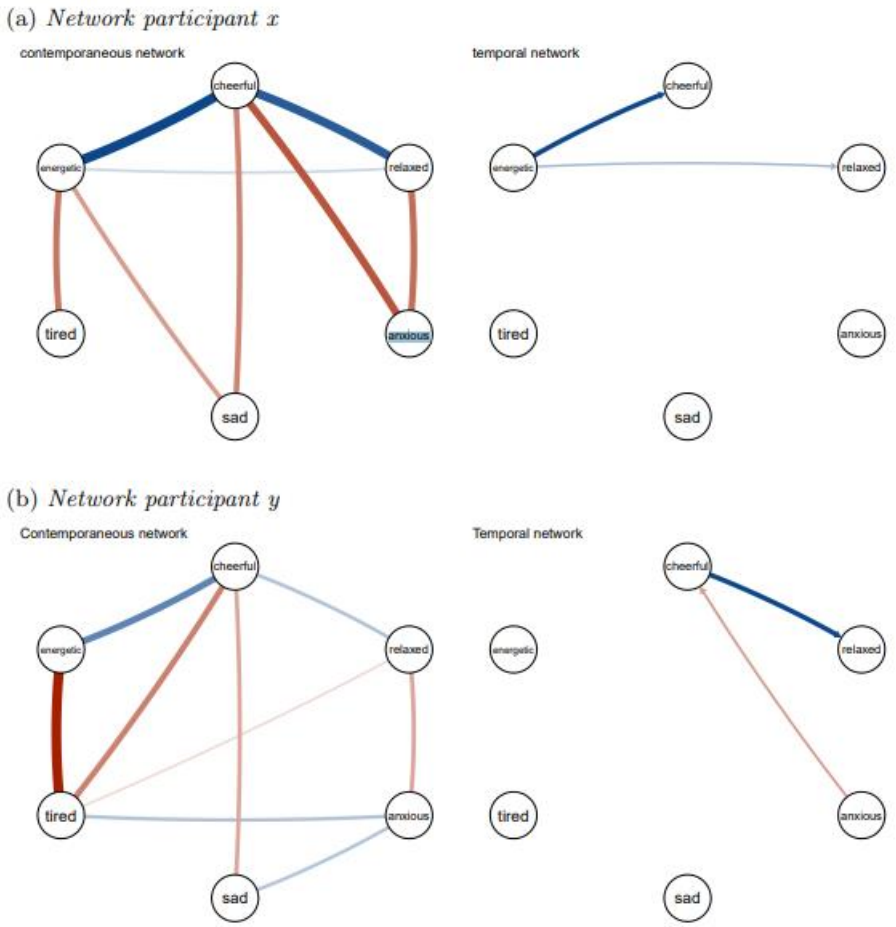
Gender differences in cannabis use disorder symptom networks.

The symptom networks of men and women are similar: no difference in *structure* (M = 0.60, p = .94), *global strength* (S = 0.11, p = .97) or *centrality* (strength: lowest p-value =.19) – Network Comparison Test.

Kroon, E., Mansueto, A., Kuhns, L., Filbey, F., Wiers, R., & Cousijn, J. (2023). Gender differences in cannabis use disorder symptoms: A network analysis. *Drug and Alcohol Dependence*, *243*, 109733. https://doi.org/10.1016/j.drugalcdep.2022.109733

van Borkulo, C., van Bork, R., Boschloo, L., Kossakowski, J., Tio, P., Schoevers, R., Borsboom, D., & Waldorp, L. (2021). Comparing Network Structures on Three Aspects: A Permutation Test. *Psychological Methods*. https://doi.org/10.1037/met0000476

GRAPHICAL VAR AND INDIVIDUAL NETWORK INVARIANCE TEST (INIT)



Affective states idiographic network structures for participant x and participant y as estimated with psychonetrics using FIML estimation and model pruning at an $\alpha = 0.05$ level. Using INIT to test for equality constraints on the pruned network structures, results indicated different network structures fit the data best for these two participants by a lower BIC value for the model without equality constraints.

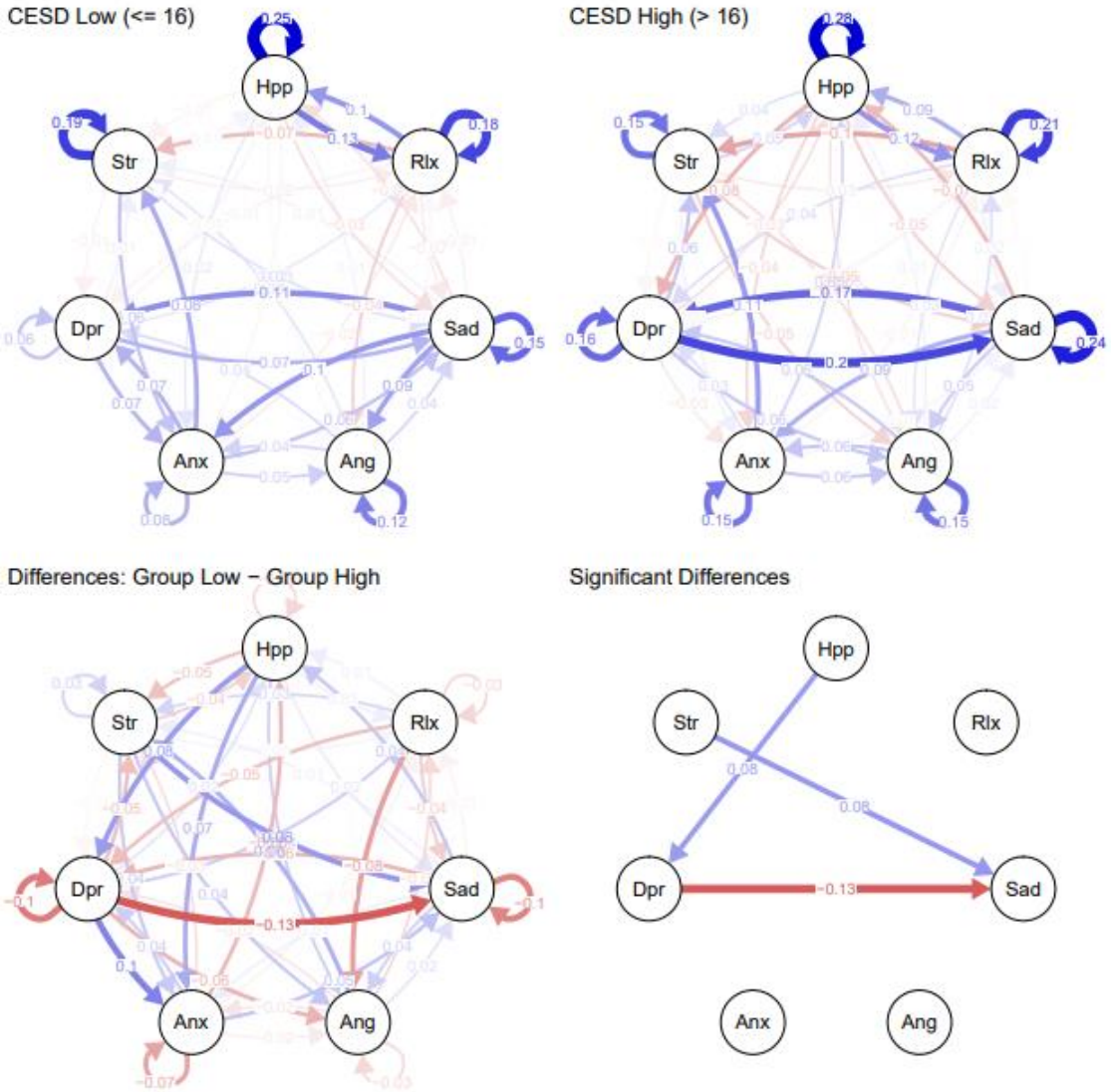
Constrained model (homogeneous, networks are equal) versus ***unconstrained*** model (heterogeneous, networks have differences).

Hoekstra, R. H. A., Epskamp, S., Nierenberg, A. A., Borsboom, D., & McNally, R. J. (2023). *Testing similarity in longitudinal networks: The Individual Network Invariance Test (INIT)*. PsyArXiv. https://doi.org/10.31234/osf.io/ugs2r

MLVAR AND TESTING FOR GROUP DIFFERENCES

Inspecting group differences in fixed lagged effects in the data on emotion states in groups with low and high depressive symptoms. *Hpp* = Happy, *Rlx* = Relaxed, *Sad* = Sad, *Ang* = Angry, *Anx* = Anxious, *Dpr* = Depressed, *Str* = Stressed.

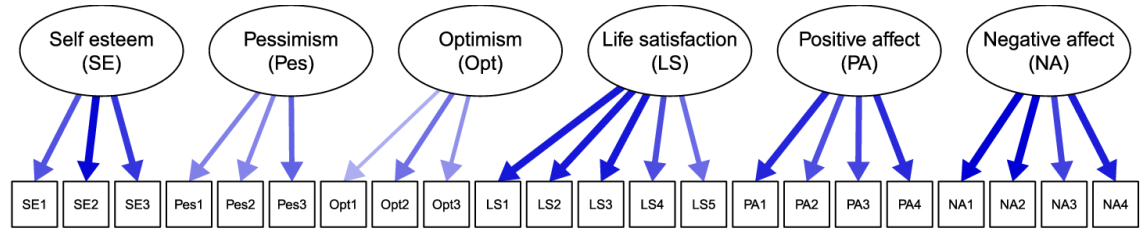
Bottom right panel shows the group differences that are significant with $\alpha = 0.05$ based on the ***permutation test.***



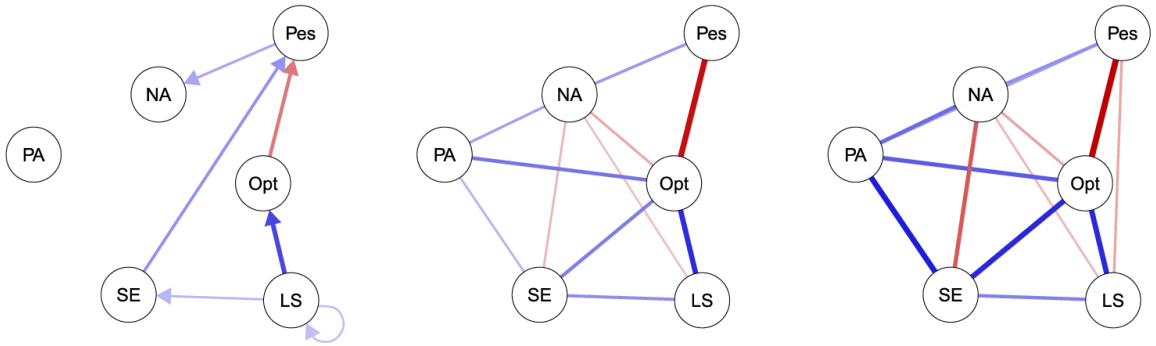
Haslbeck, J., Epskamp, S., & Waldorp, L. (2023). *Testing for Group Differences in Multilevel Vector Autoregressive Models*. PsyArXiv. https://doi.org/10.31234/osf.io/dhp8s

PANEL DATA: DYNAMIC LAG-1 LATENT VARIABLE MODEL OR CROSS-LAGGED NETWORK MODELS (CLNM)?

Self-esteem, optimism, and pessimism



(a) Estimated factor loadings



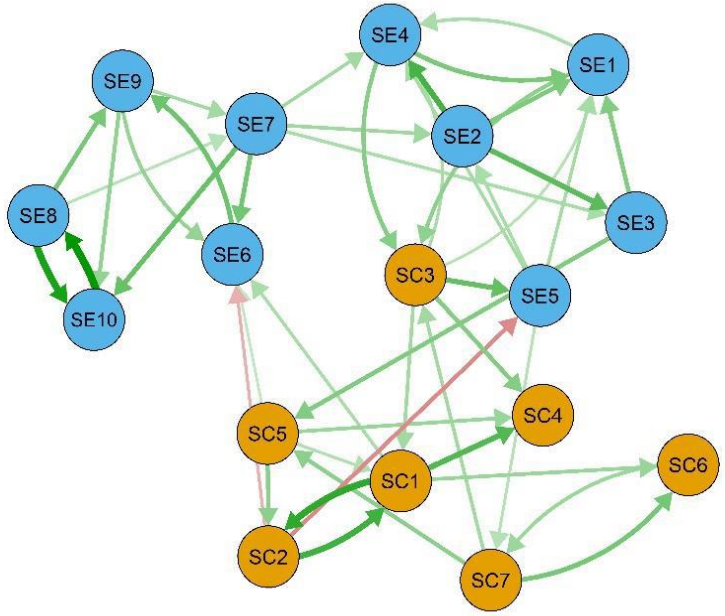
(b) Estimated temporal network, standardized to partial directed correlations.

(c) Estimated contemporaneous partial correlation network.

(d) Estimated between-subjects partial correlation network.

Epskamp, S. (2020). Psychometric network models from time-series and panel data. *Psychometrika*, *85*(1), 206–231. https://doi.org/10.1007/s11336-020-09697-3

Commitment to school and self-esteem



Wysocki, A., Rhemtulla, M., Van Bork, R., & Cramer, A. O. J. (2022). *Cross-Lagged Network Models* [Preprint]. PsyArXiv. https://doi.org/10.31234/osf.io/vjr8z

- SC1: I like school a lot (R)
- SC2: School bores me
- SC3: I don't do well at school
- SC4: I don't belong at school
- SC5: Homework is a waste of time
- SC6: I try hard at school (R)
- SC7: I finish my homework (R)
- SE1: I'm a person of worth (R)
- SE2: I have a number of good qualities (R)
- SE3: I'm a failure
- SE4: I am able to do things as well as most people (R)
- SE5: I do not have much to be proud of
- SE6: I take a positive attitude toward myself (R)
- SE7: I am satisfied with myself (R)
- SE8: I feel useless at times
- SE9: I wish I could have more respect for myself
- SE10:I think I am no good at all

IF YOU WANT TO HAVE A DEEP-DIVE

PSYCHOSYSTEMS

- Psychological Networks Amsterdam Summer/Winter Schools http://psychosystems.org/workshops/

- The first Asian school on network psychometrics by Sacha Epskamp and Adela Isvoranu https://fass.nus.edu.sg/psy/network-psychometrics-for-behavioral-and-social-scientists/

NUS National University of Singapore | Department of Psychology Faculty of Arts & Social Sciences

- Università Cattolica di Sacro Cuore and the University of Milano-Bicocca: stay tuned for new editions https://formazionecontinua.unicatt.it/formazione-introduzione-alla-psychometric-network-analysis-in-psicologia-p223mi081614-01

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ADDITIONAL REFERENCES (BASED ON THE DISCUSSION)

- Variable selection:

Burger, J., Isvoranu, A.-M., Lunansky, G., Haslbeck, J., Epskamp, S., Hoekstra, R. H. A., Fried, E. I., Borsboom, D., & Blanken, T. (2020). *Reporting Standards for Psychological Network Analyses in Cross-sectional Data*. PsyArXiv. https://doi.org/10.31234/osf.io/4y9nz

Flake, J. K., & Fried, E. I. (2020). Measurement Schmeasurement: Questionable Measurement Practices and How to Avoid Them. *Advances in Methods and Practices in Psychological Science*, *3*(4), 456–465. https://doi.org/10.1177/2515245920952393

- Power analysis in psychological networks:

Epskamp, S., Borsboom, D., & Fried, E. I. (2018). Estimating psychological networks and their accuracy: A tutorial paper. *Behavior Research Methods*, *50*(1), 195–212. https://doi.org/10.3758/s13428-017-0862-1

- Random effects in MLVAR:

Jordan, D. G., Winer, E. S., & Salem, T. (2020). The current status of temporal network analysis for clinical science: Considerations as the paradigm shifts? *Journal of Clinical Psychology*, *76*. https://doi.org/10.1002/jclp.22957

- Exploratory Graph Analysis:

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. https://doi.org/10.1371/journal.pone.0174035

- Network and latent variable modeling:

Epskamp, S., Rhemtulla, M., & Borsboom, D. (2017). Generalized Network Psychometrics: Combining Network and Latent Variable Models. *Psychometrika*, *82*(4), 904–927. https://doi.org/10.1007/s11336-017-9557-x

- GIMME:

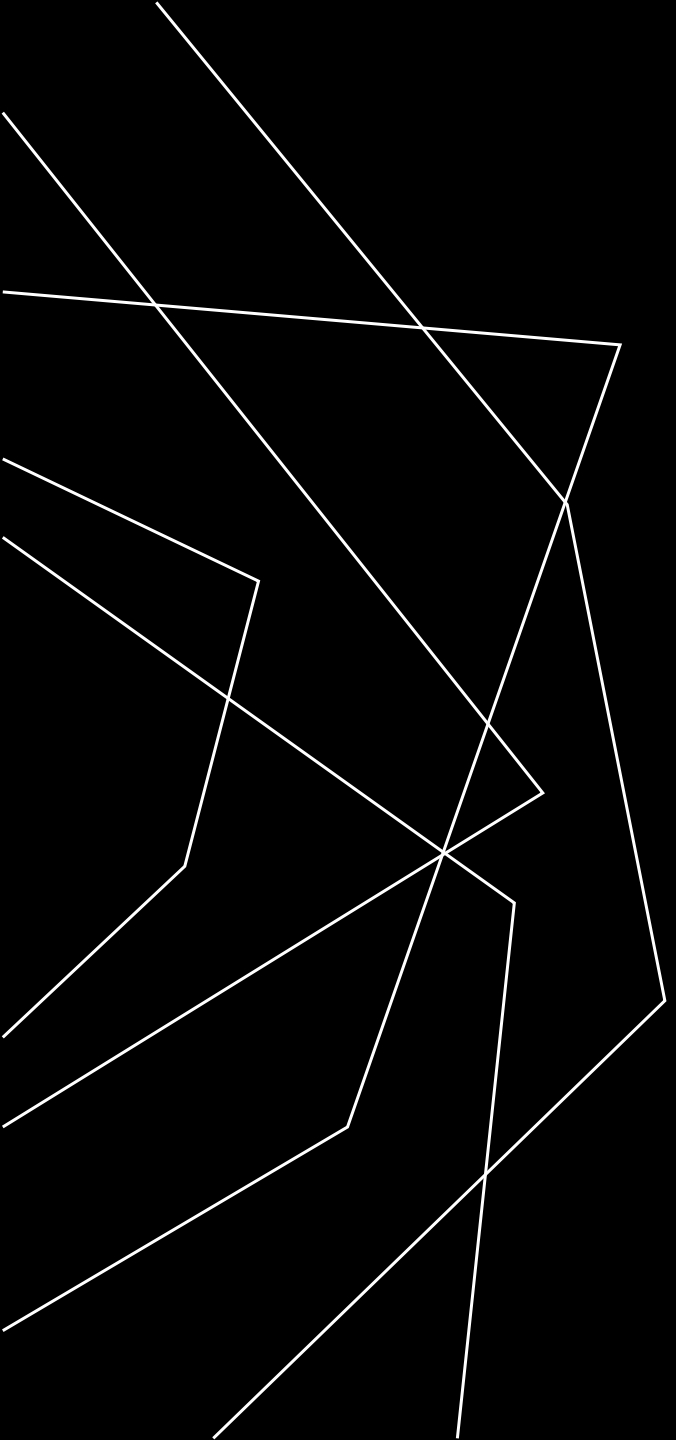
Psychology: Boele, S., Bülow, A., Beltz, A. M., De Haan, A., Denissen, J. J. A., De Moor, M., & Keijsers, L. (2023). *Like No Other? A Family-Specific Network Approach to Parenting Adolescents* [Preprint]. PsyArXiv. https://doi.org/10.31234/osf.io/a6gn3

Neuroscience (not exactly the network analysis as used in psychometrics): Beltz, A. M., & Gates, K. M. (2017). Network Mapping with GIMME. *Multivariate Behavioral Research*, *52*(6), 789–804. https://doi.org/10.1080/00273171.2017.1373014

General resource (thanks to Ethan McCormick for the link): https://tarheels.live/gimme/

- Ergodicity Information Index (interindividual versus intraindividual approach):

Golino, H., Christensen, A. P., & Nesselroade, J. (2022). Towards a psychology of individuals: The ergodicity information index and a bottom-up approach for finding generalizations. PsyArXiv. https://doi.org/10.31234/osf.io/th6rm



THANK YOU!

QUESTIONS?