Personalized Network Analysis

e-coaching for Health and Wellbeing

Sacha Epskamp

University of Amsterdam: Department of Psychological Methods

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Two Trends in Clinical Psychology

Time-series Data

	id	day	beep	cheerful	pleasant	worry	fearful	sad	relaxed
1	10720	1	1	NA	NA	NA	NA	NA	NA
2	10720	1	2	NA	NA	NA	NA	NA	NA
3	10720	1	3	NA	NA	NA	NA	NA	NA
4	10720	1	4	4	3	6	5	4	2
5	10720	1	5	2	1	5	4	4	2
6	10720	1	6	3	2	5	3	5	5
7	10720	1	7	NA	NA	NA	NA	NA	NA
8	10720	1	8	2	2	6	5	3	2
9	10720	1	9	NA	NA	NA	NA	NA	NA
10	10720	1	10	NA	NA	NA	NA	NA	NA
11	10720	1	NA	NA	NA	NA	NA	NA	NA
12	10720	2	1	5	2	5	3	5	5
13	10720	2	2	5	-3	6	2	3	5
14	10720	2	3	3	1	6	3	5	3
15	10720	2	4	5	-2	5	3	4	4
16	10720	2	5	NA	NA	NA	NA	NA	NA
17	10720	2	6	4	2	4	2	3	5
18	10720	2	7	NA	NA	NA	NA	NA	NA
19	10720	2	8	4	2	5	2	2	5
20	10720	2	9	5	3	2	1	2	6
21	10720	2	10	6	3	2	1	2	5
22	10720	2	NA	NA	NA	NA	NA	NA	NA
23	10720	3	1	NA	NA	NA	NA	NA	NA
24	10720	3	2	3	2	5	2	4	3
25	10720	3	3	3	-2	5	2	3	2
26	10720	3	4	4	-3	5	1	3	4
27	10720	3	5	4	2	5	2	3	5
28	10720	3	6	5	3	3	2	2	5
29	10720	3	7	5	3	5	2	2	5

Network Approach

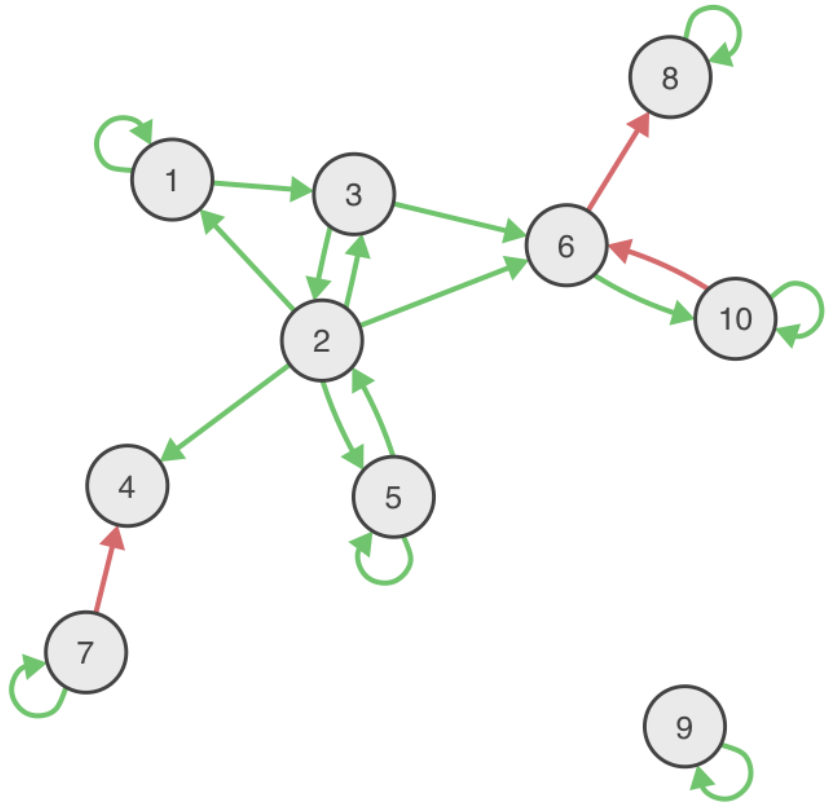
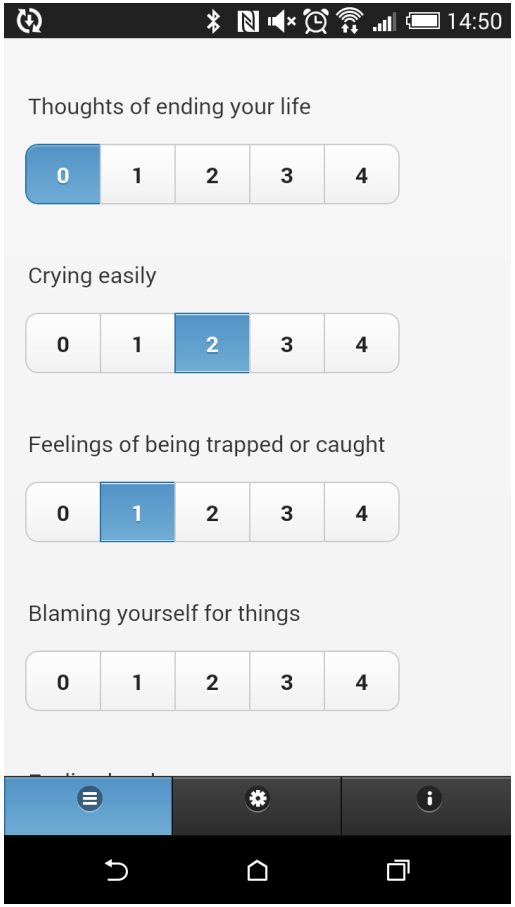


Figure by Eiko Fried

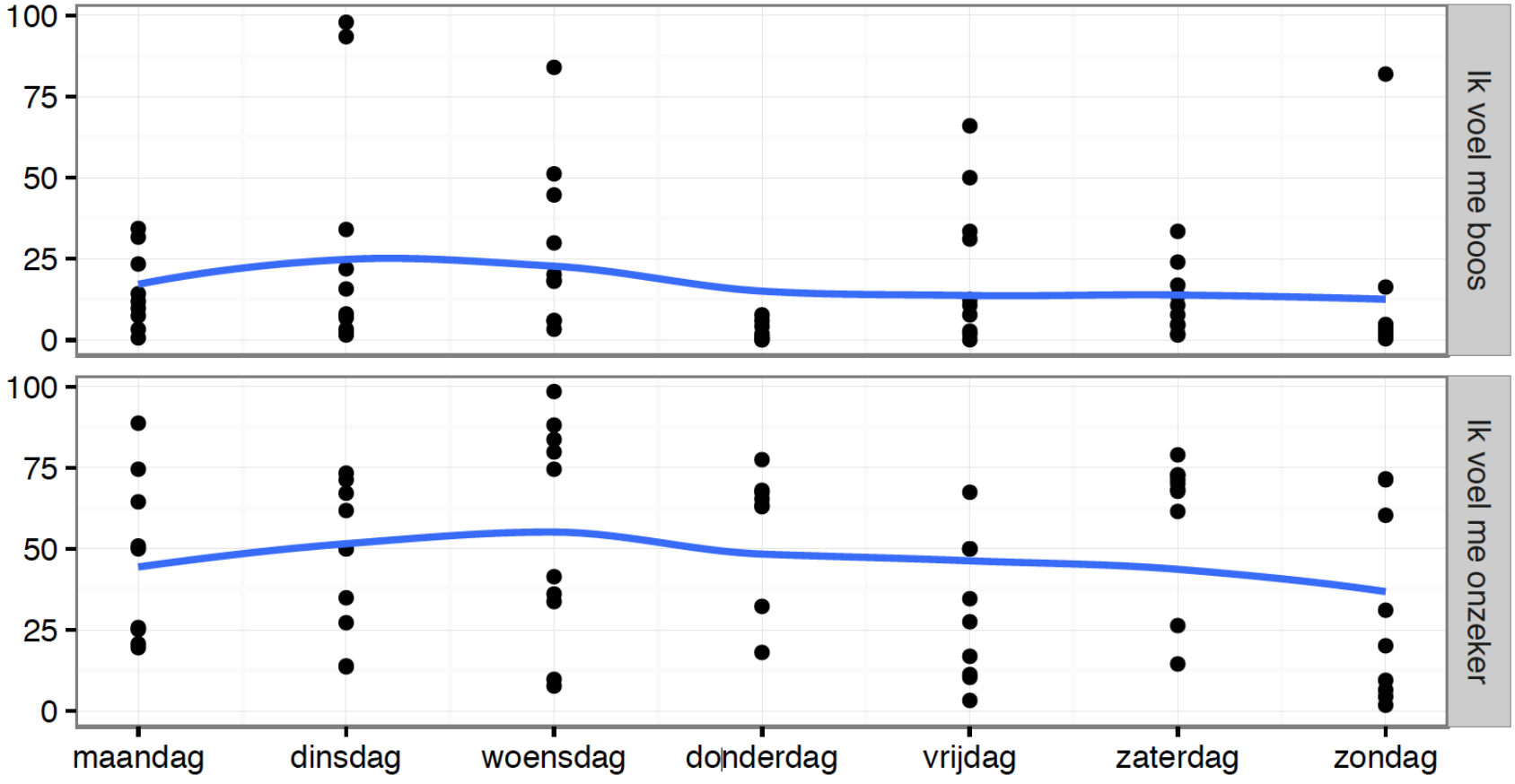
Time-series Data



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

- Patients carry a smartphone or device that beeps several times per day. The patient then fills in a short questionare on how he or she is feeling
- Called Experience Sampling Method (ESM) or Ecological Momentary Assessment (EMA)

Time-series in Clinical Practice

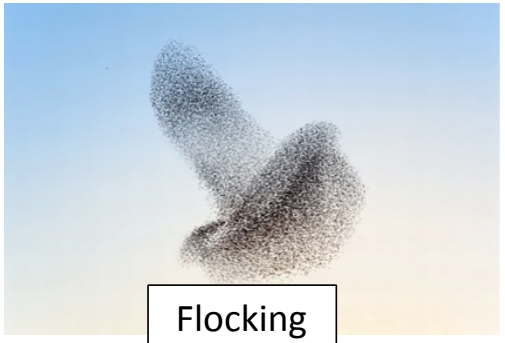


- Objective data to therapist
- Insight in life of the patient

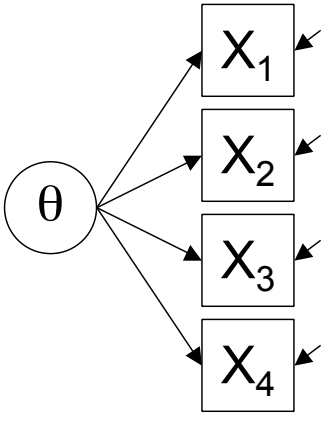
The Network Approach to Psychopathology

Disease analogy

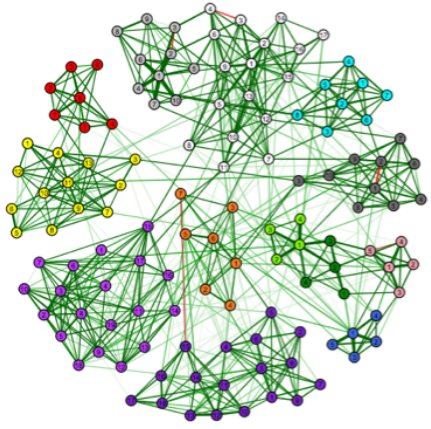
Mental health problems



Flocking analogy



Latent variable model

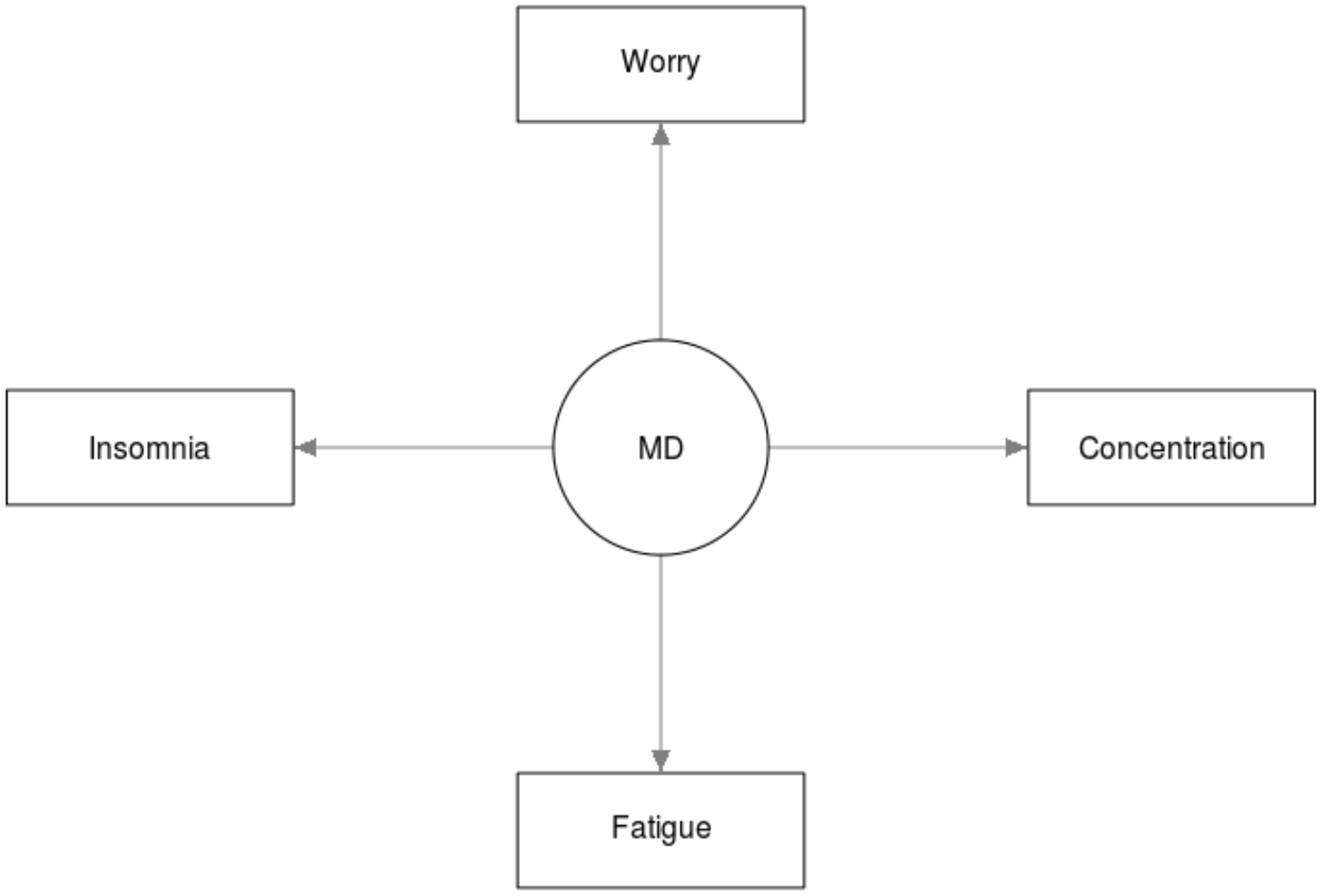


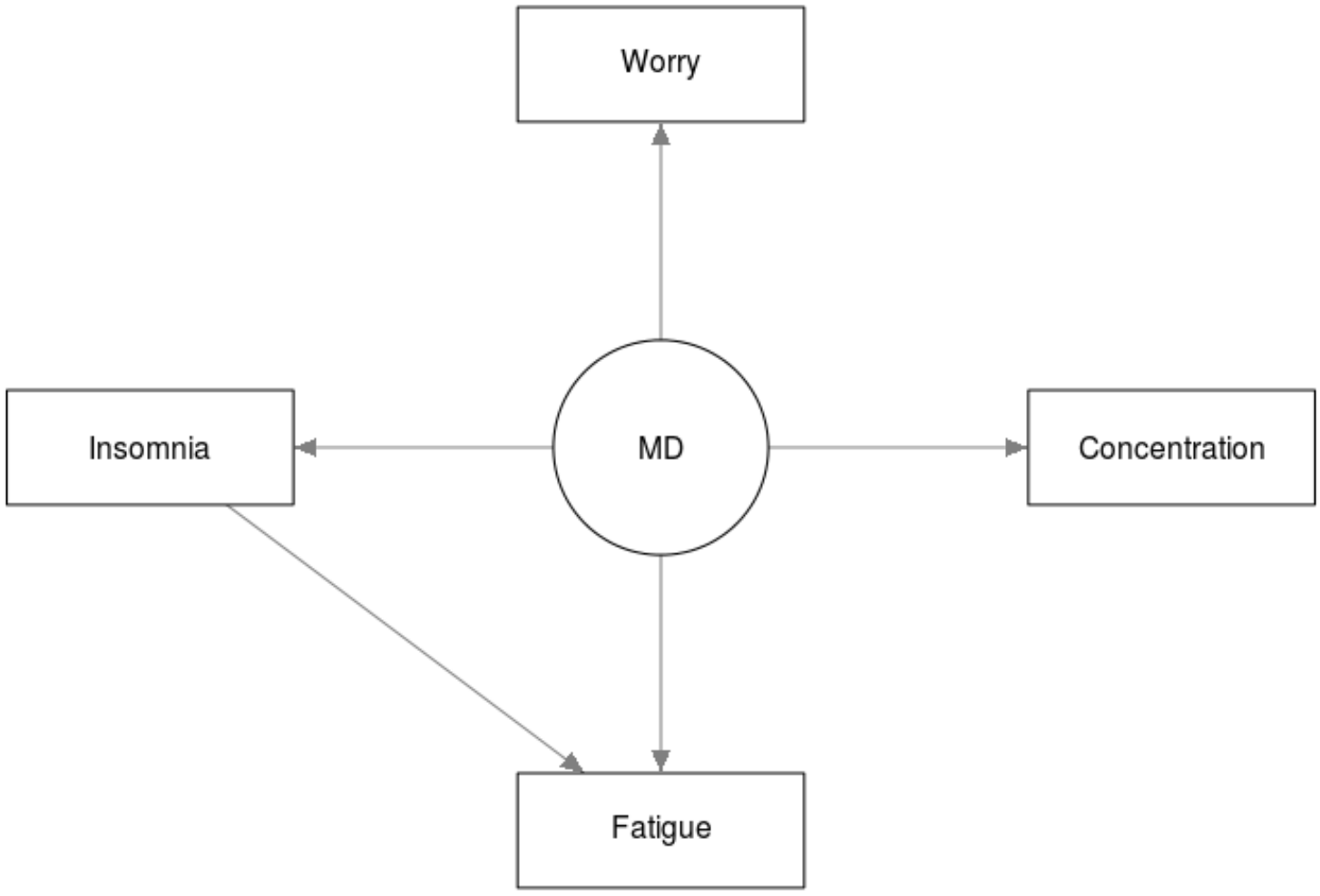
Network model

The Network Approach to Psychopathology

Denny Borsboom

Angélique Cramer


Worry
Insomnia
MD
Concentration
Fatigue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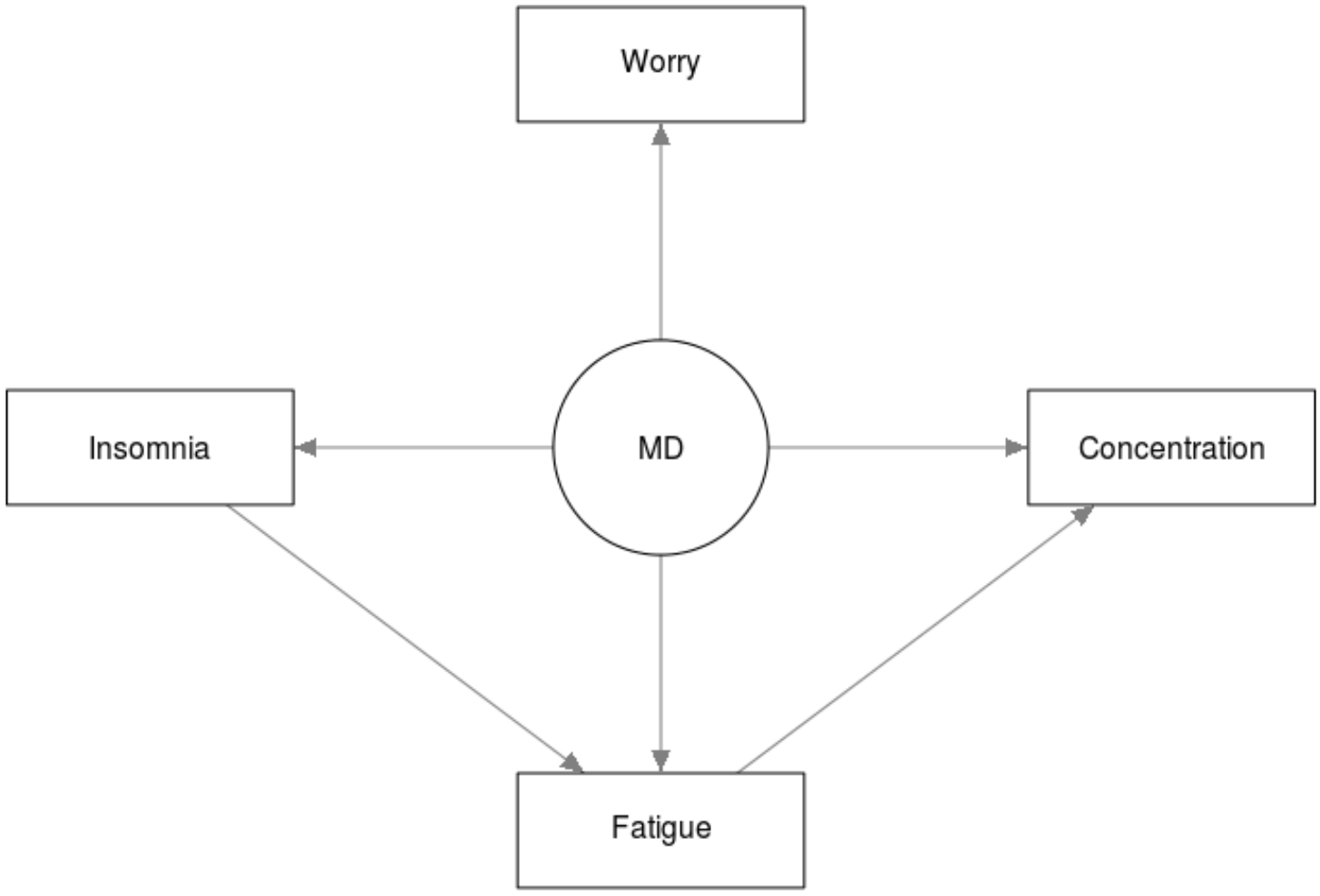
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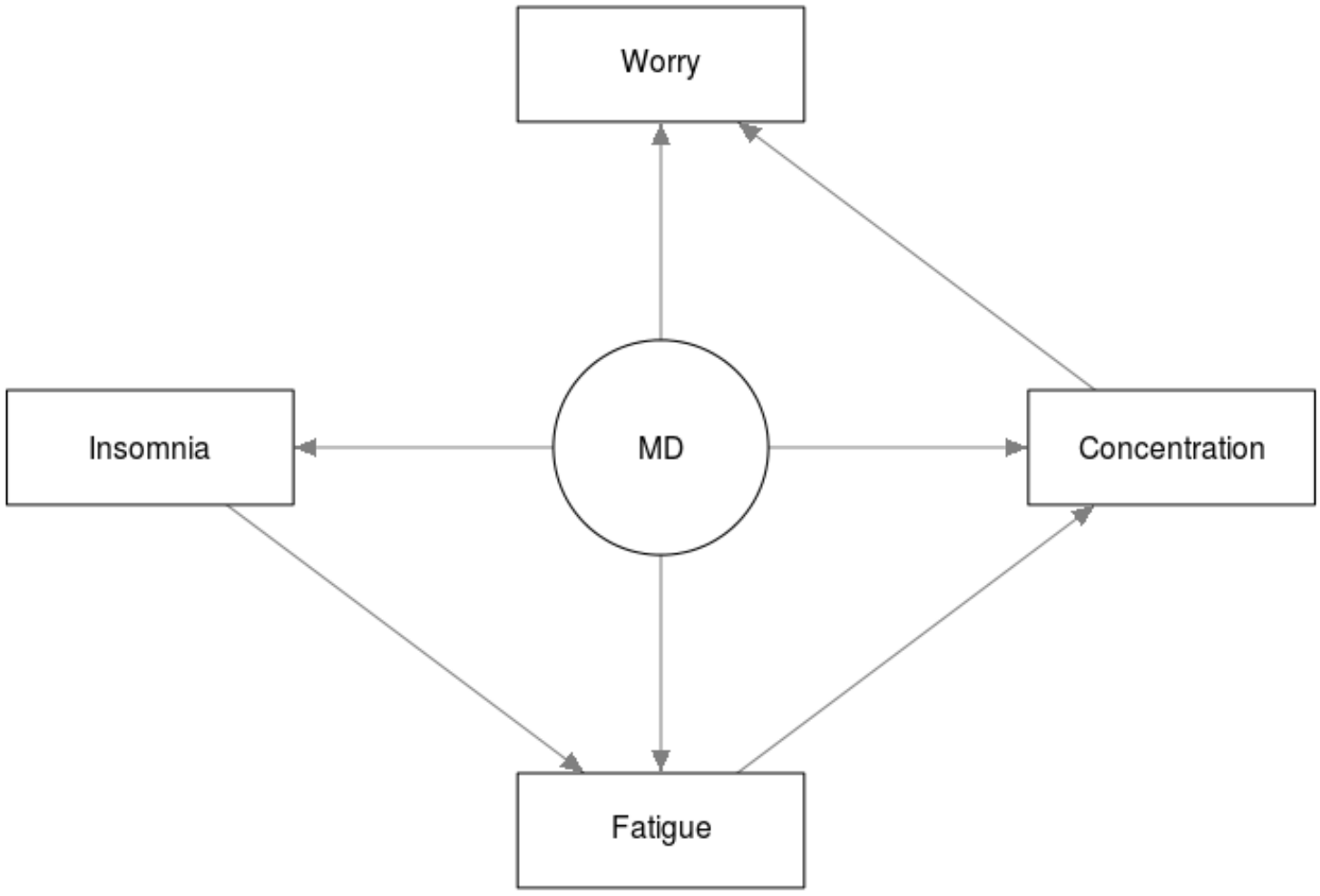
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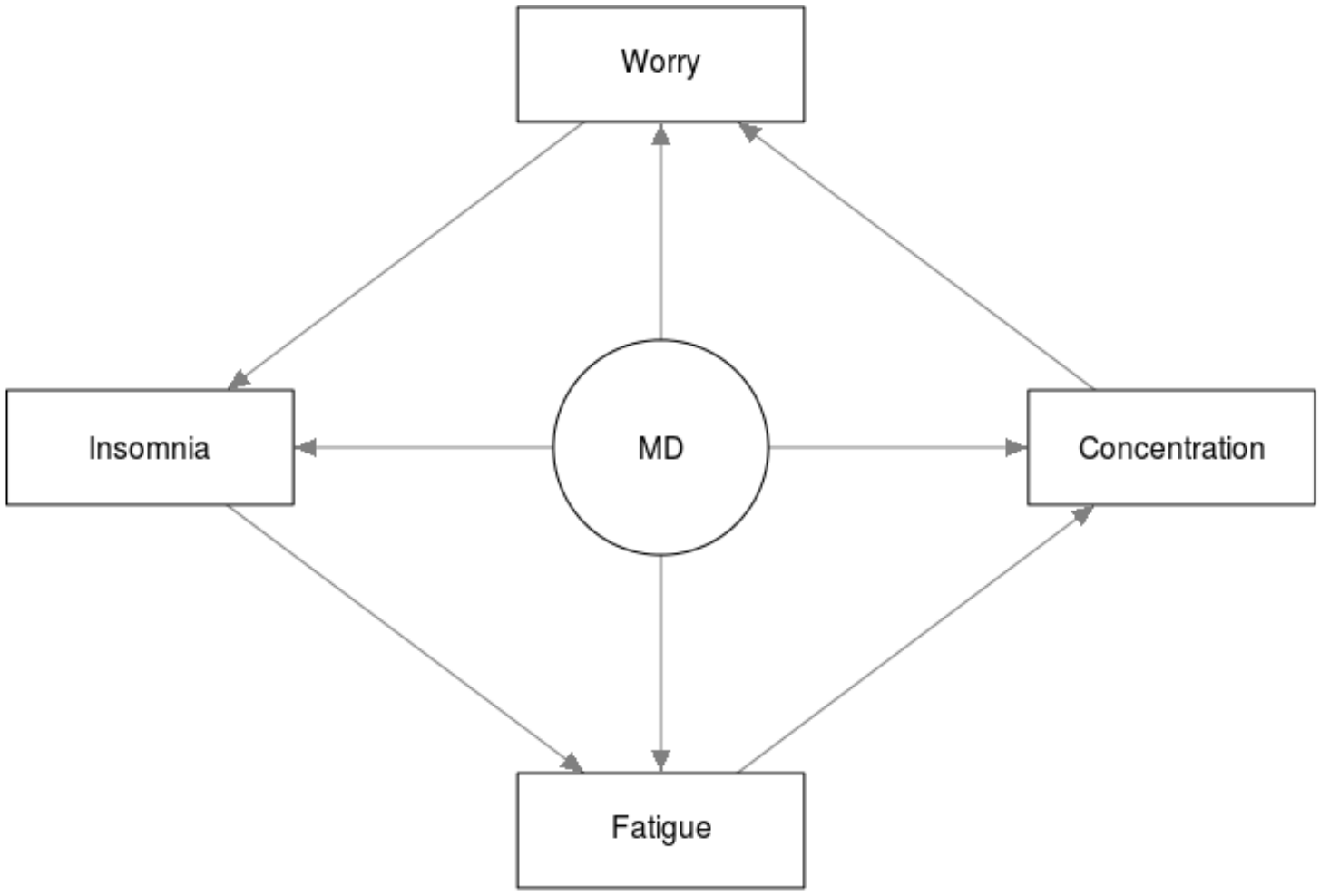
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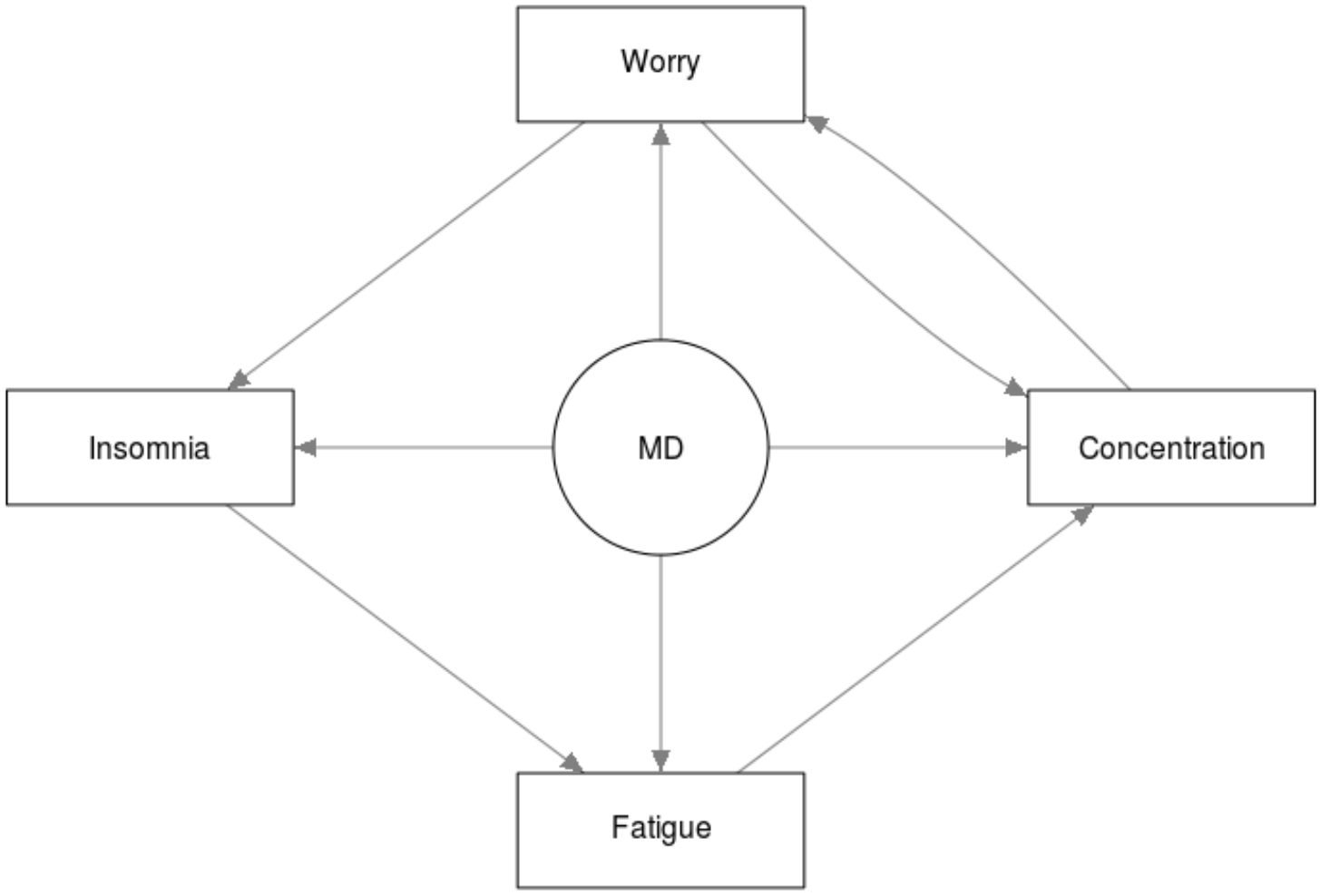
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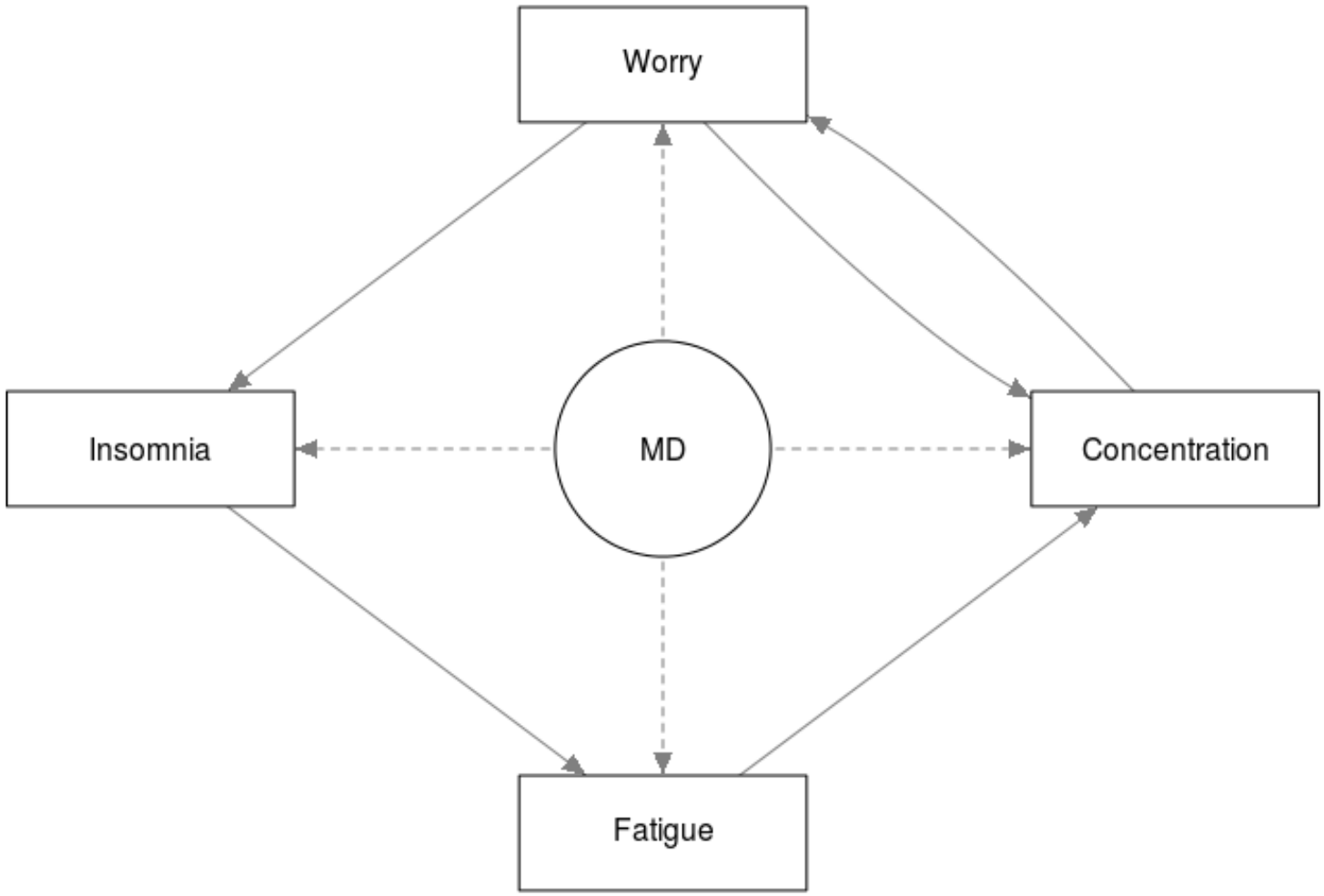
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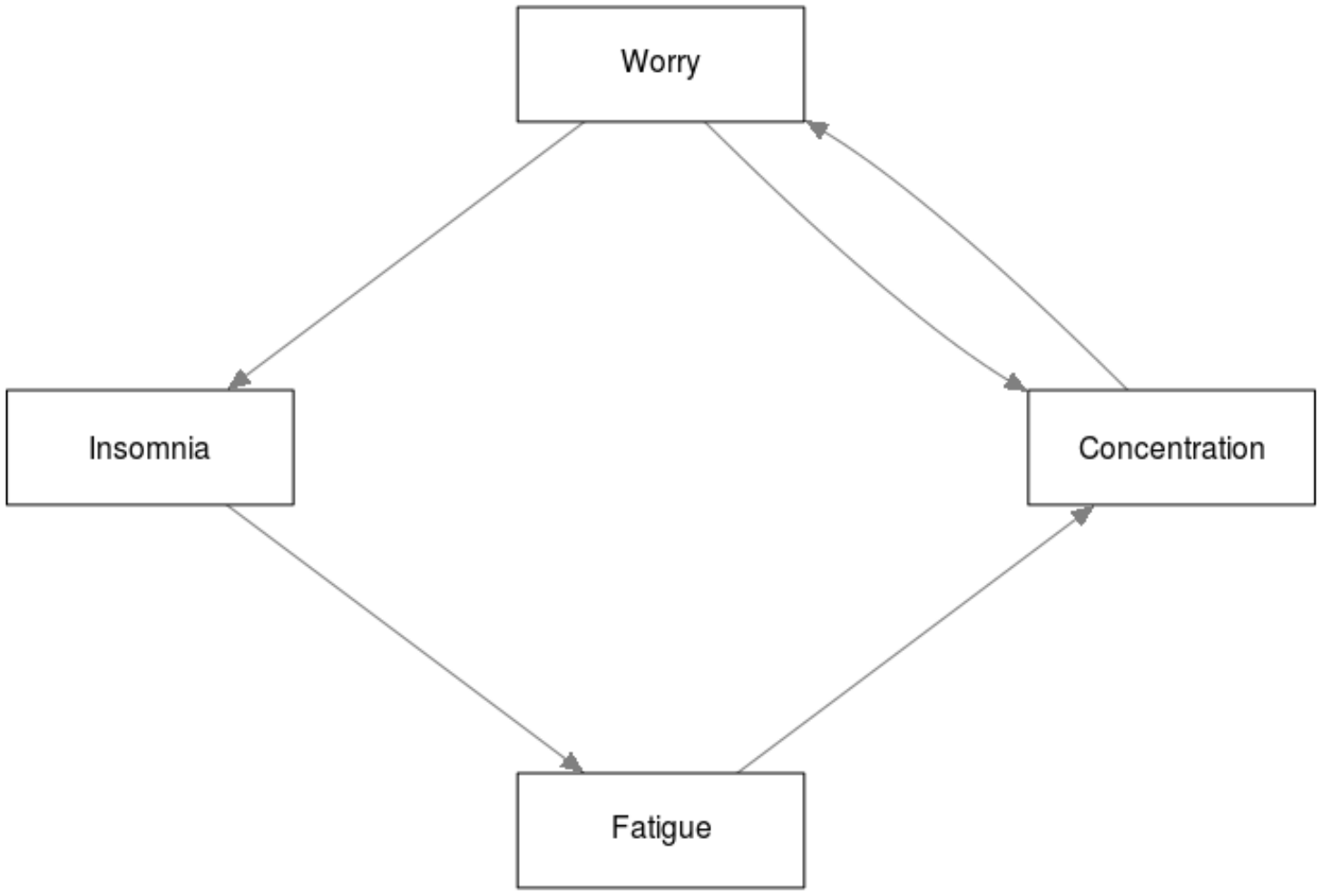
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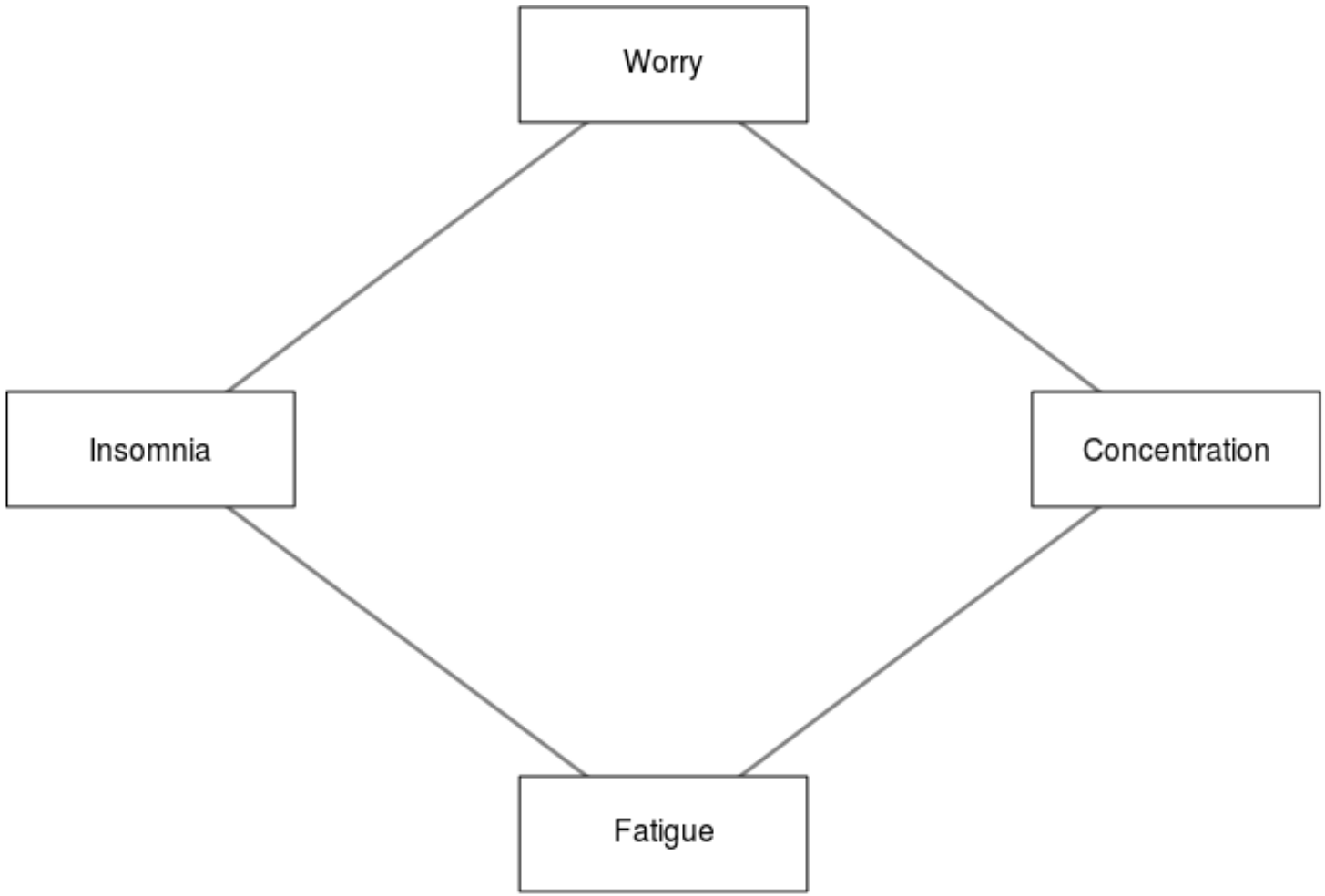
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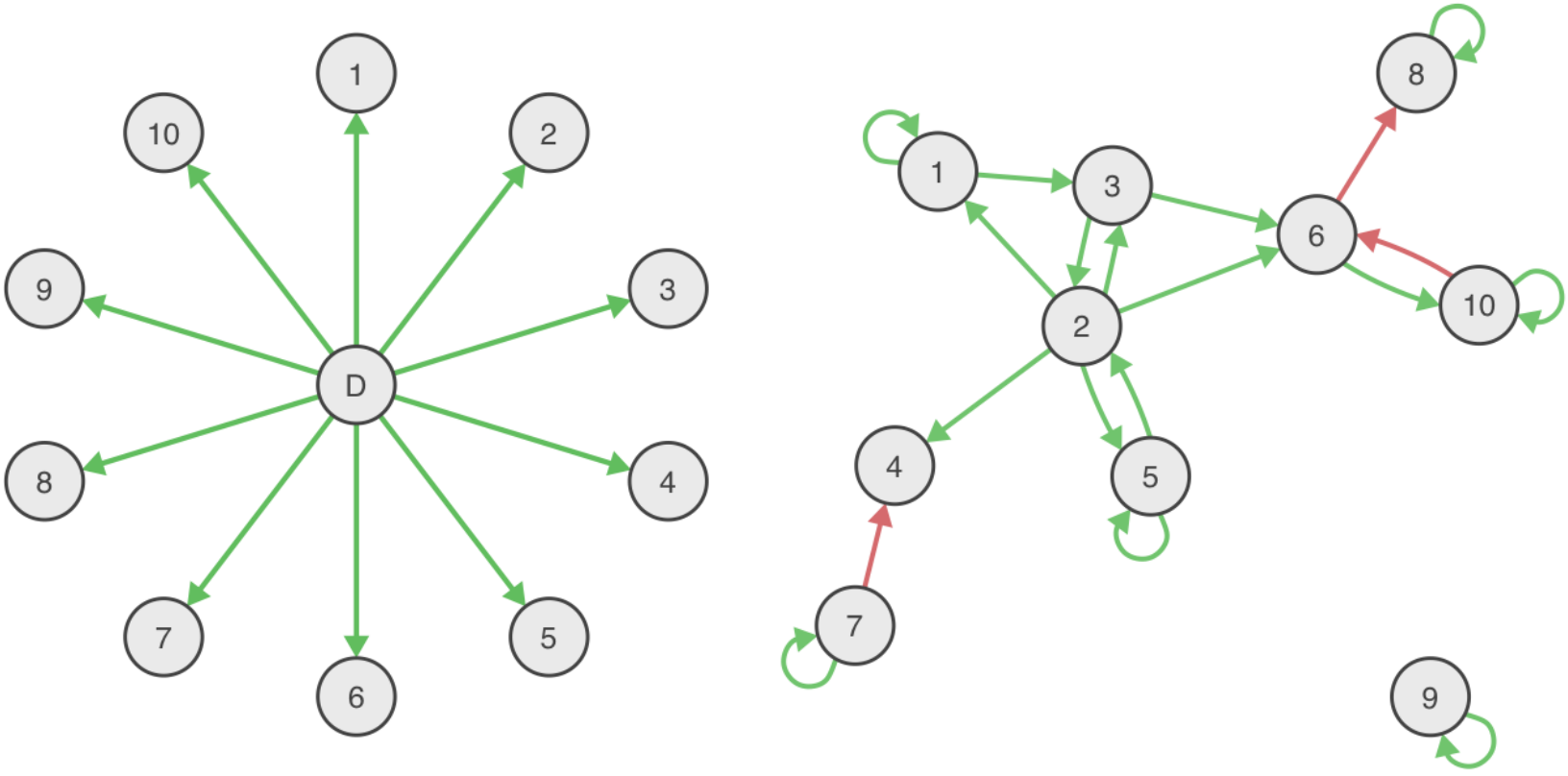


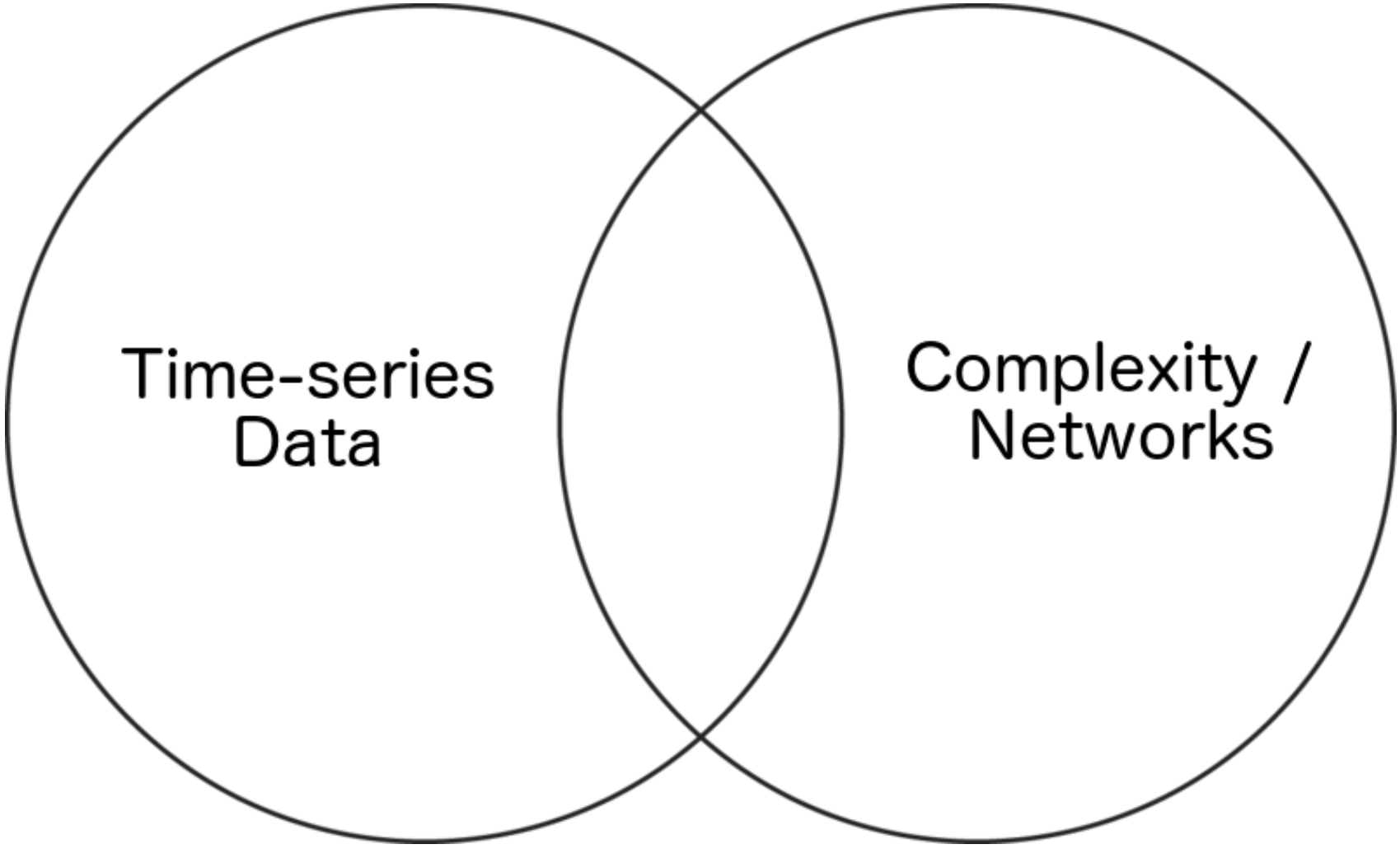
- Symptoms as separate entities that differ in important aspects
- More than interchangeable indicators of underlying disorder

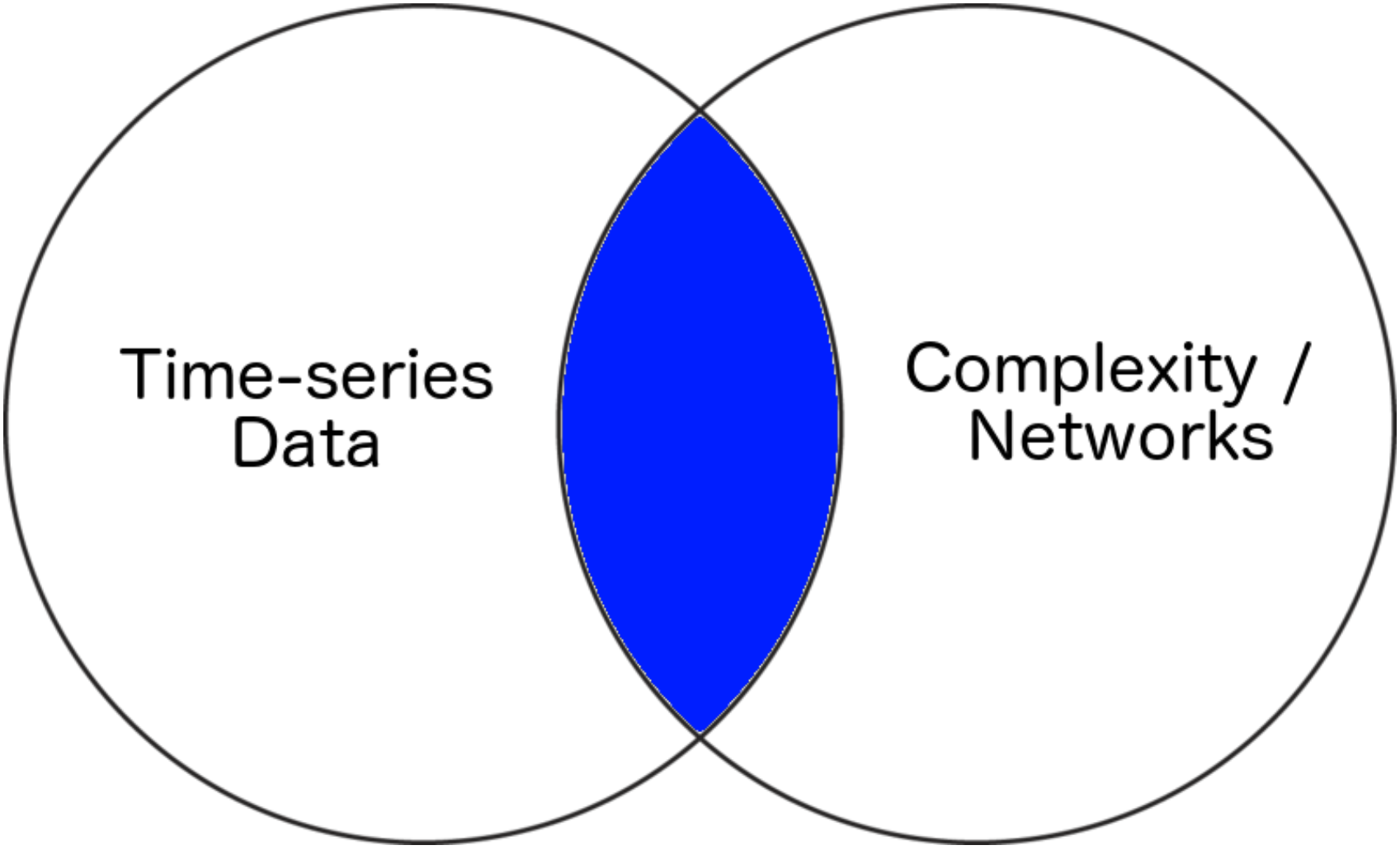
Implications Network Approach:

- Psychology as a complex system
- Symptom level treatment
- Personalized treatment
- The disorder is the system

Utility of network models:

- Exploratory insight into the problems of a patient
- Hypothesis-generating
- Extra tool in therapy


Time-series
Data
Complexity /
Networks


Time-series
Data
Complexity /
Networks

Time-series Data and the Network Approach

Three applications:

- Personalized care
- Early-warning signals
- General understanding

Network Models in Personalized Care

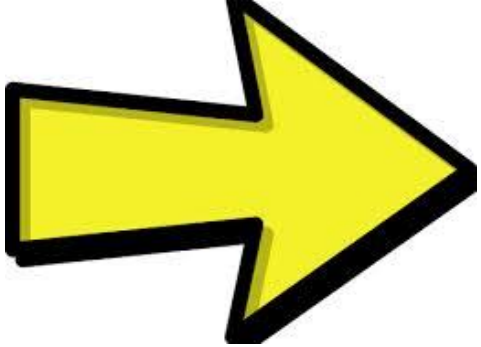
Network Models in Personalized Care

Hariette Riesse

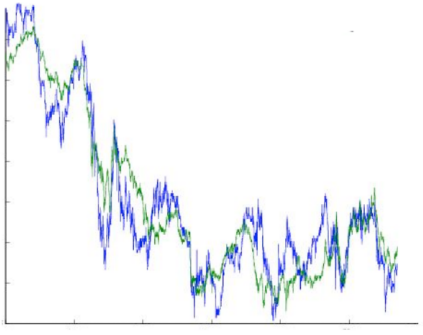
Date van der Veen

Michelle Servaas

umcg



The Psych Systems Project



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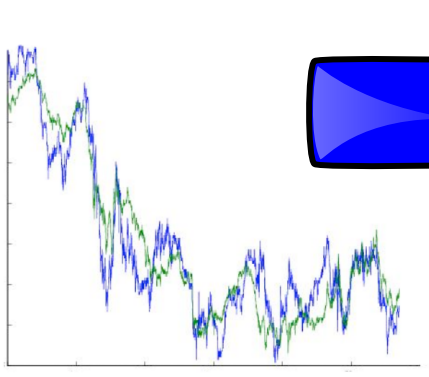

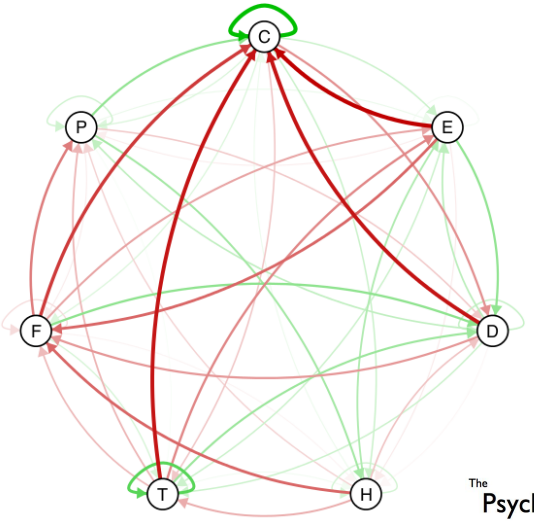

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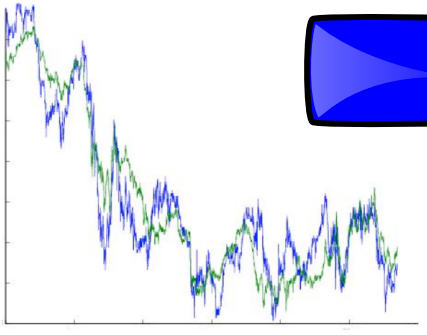

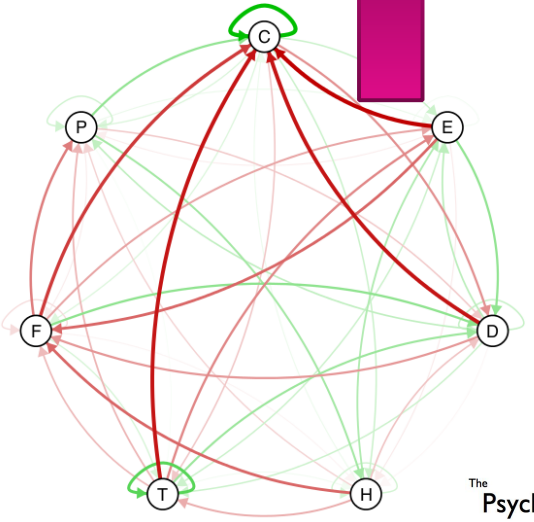

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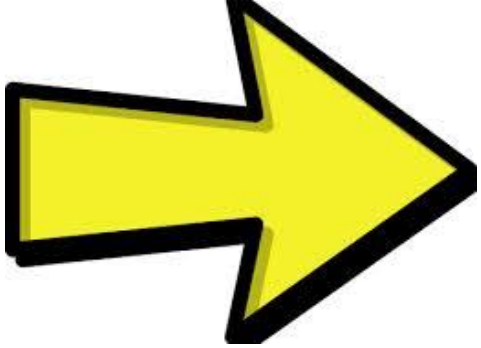

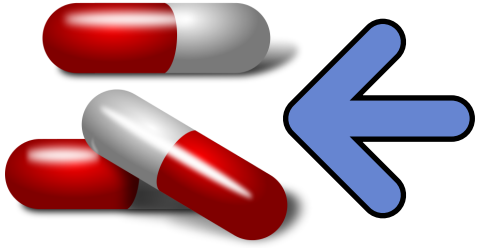

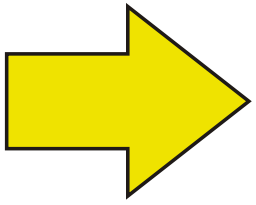

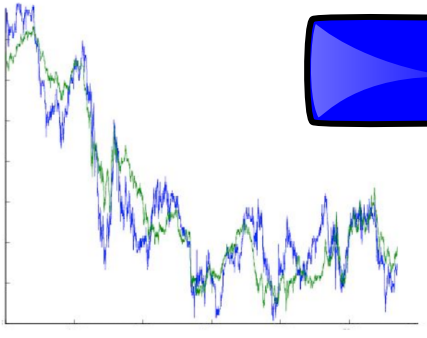

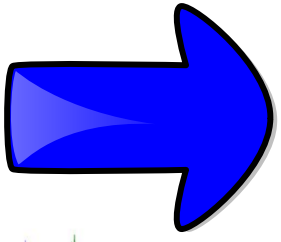

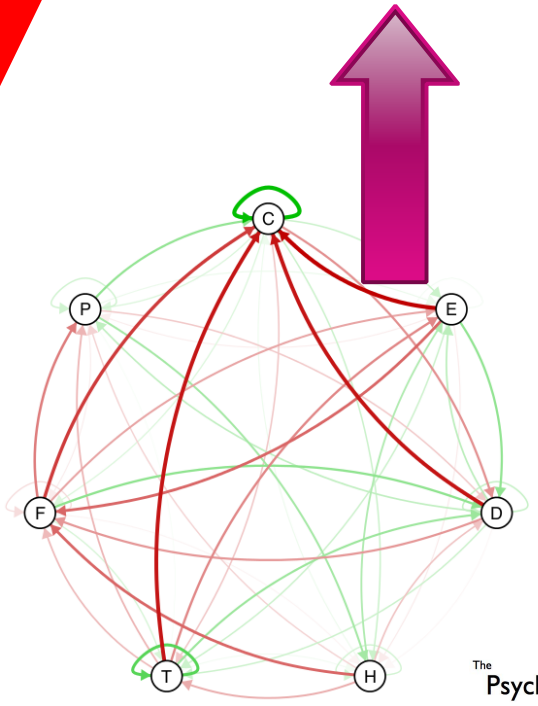

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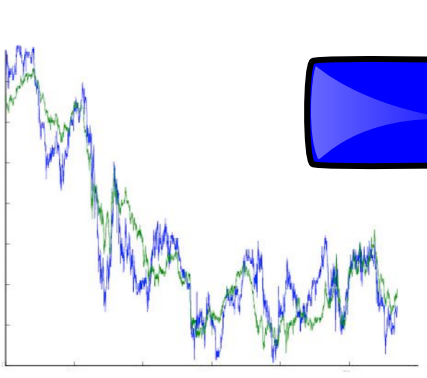

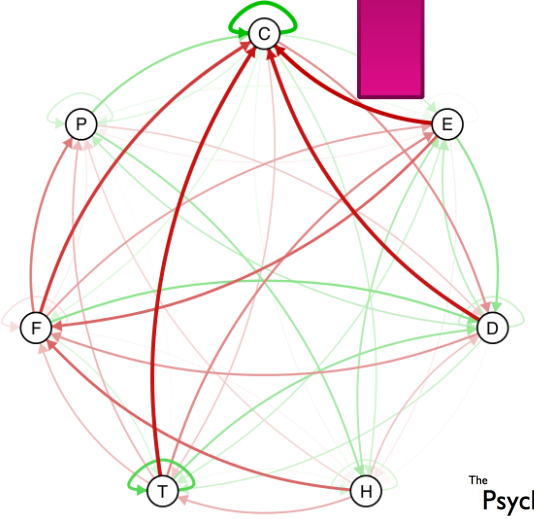

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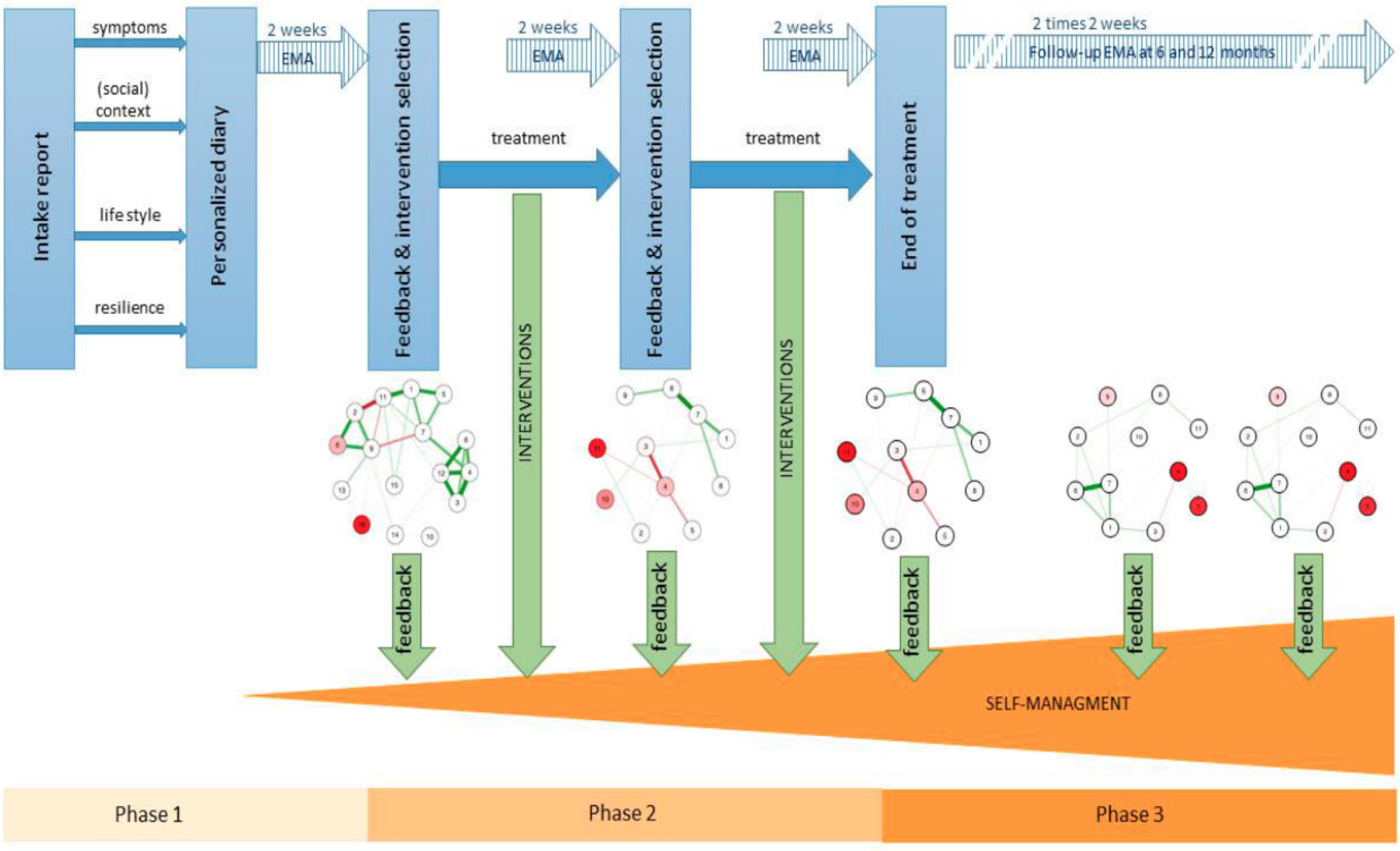
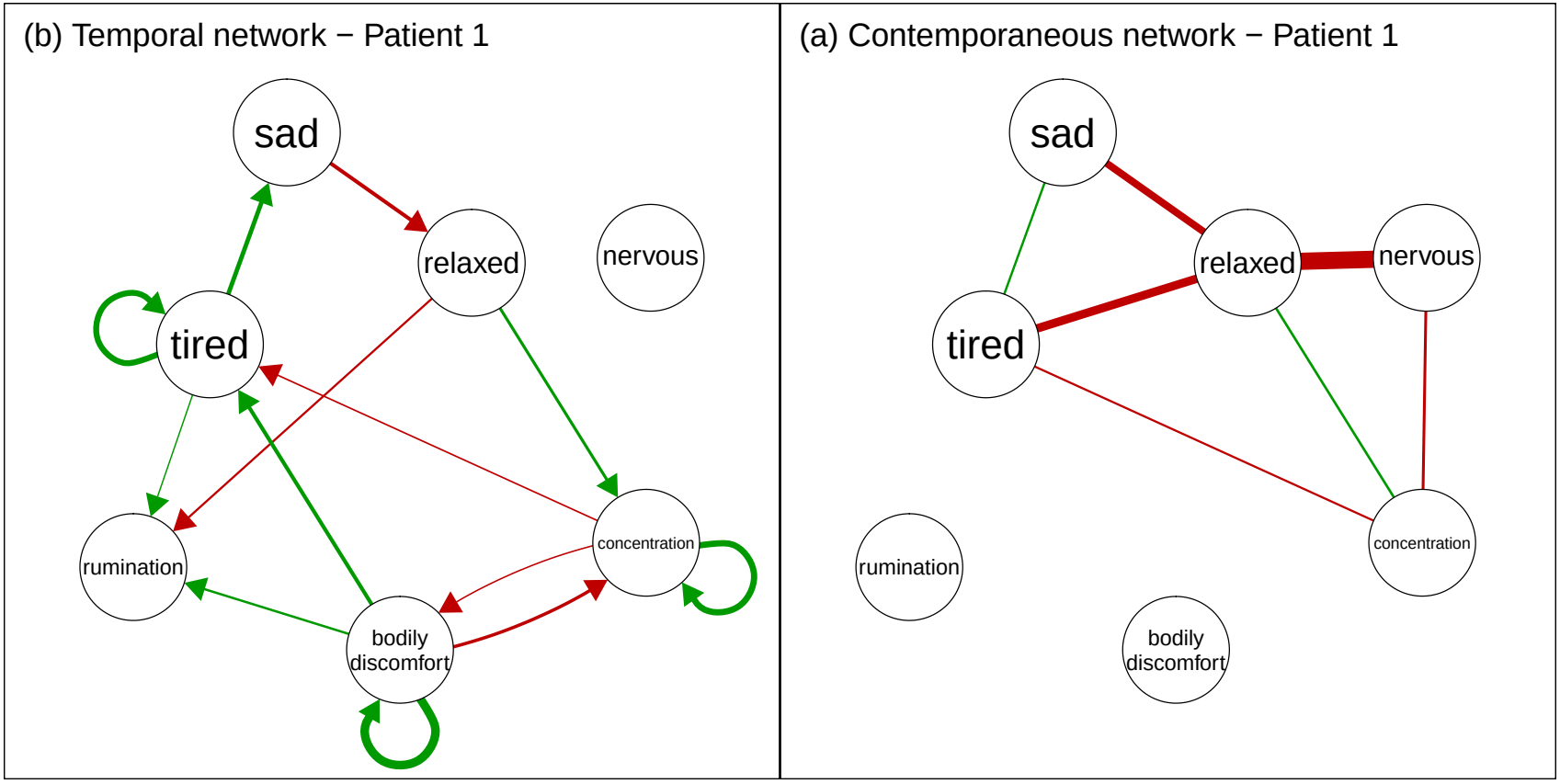

Intake report
symptoms
(social) context
life style
resilience
Personalized diary
2 weeks EMA
Feedback & intervention selection
treatment
2 weeks EMA
Feedback & intervention selection
treatment
2 weeks EMA
End of treatment
2 times 2 weeks
Follow-up EMA at 6 and 12 months
INTERVENTIONS
INTERVENTIONS
feedback
feedback
feedback
feedback
feedback
SELF-MANAGMENT
Phase 1
Phase 2
Phase 3

Personalized Networks in Clinical Practice



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

Personalized Network Modeling in Psychopathology: The Importance of Contemporaneous and Temporal Connections

Sacha Epskamp[1], Claudia D. van Borkulo[1], Date C. van der Veen[2], Michelle N. Servaas[2], Adela-Maria Isvoranu[1], Harriëtte Riese[2], Angelique O.J. Cramer[1]

1. University of Amsterdam, Department of Psychological Methods

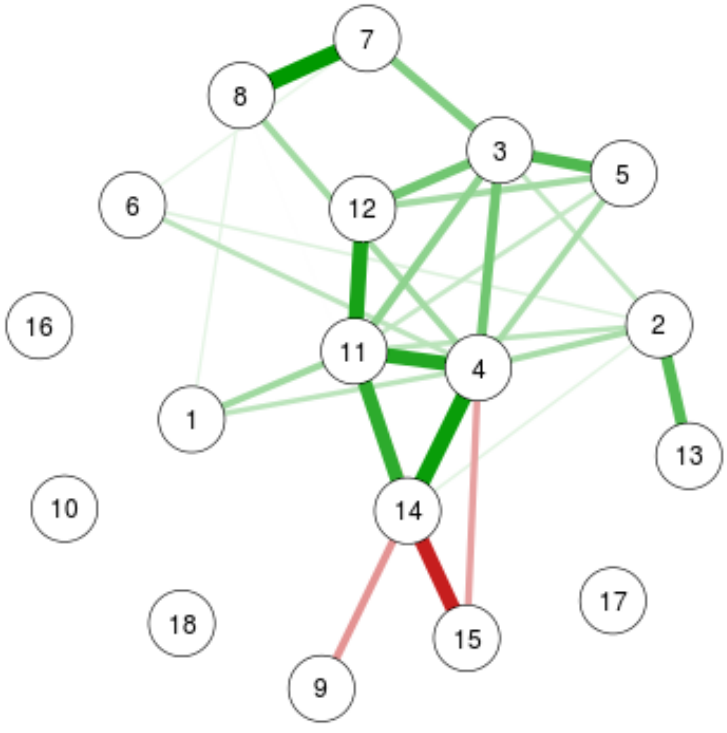
2. University of Groningen, University Medical Center Groningen, Department of Psychiatry, Interdisciplinary Center for Psychopathology and Emotion Regulation

Empirical Example 2

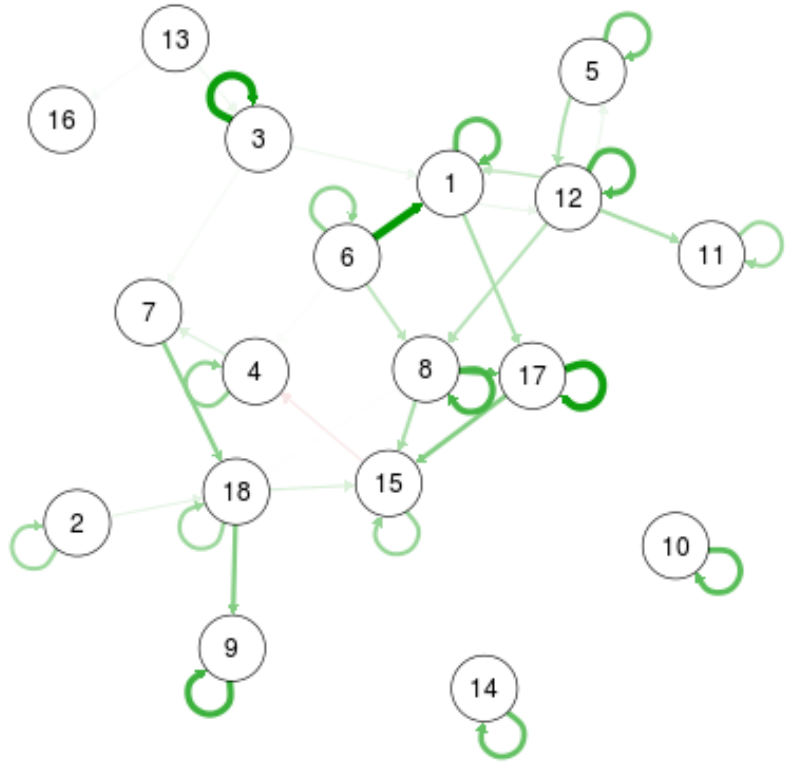
Data collected by Date C. Van der Veen, in collaboration with Harriette Riese and Renske Kroeze.

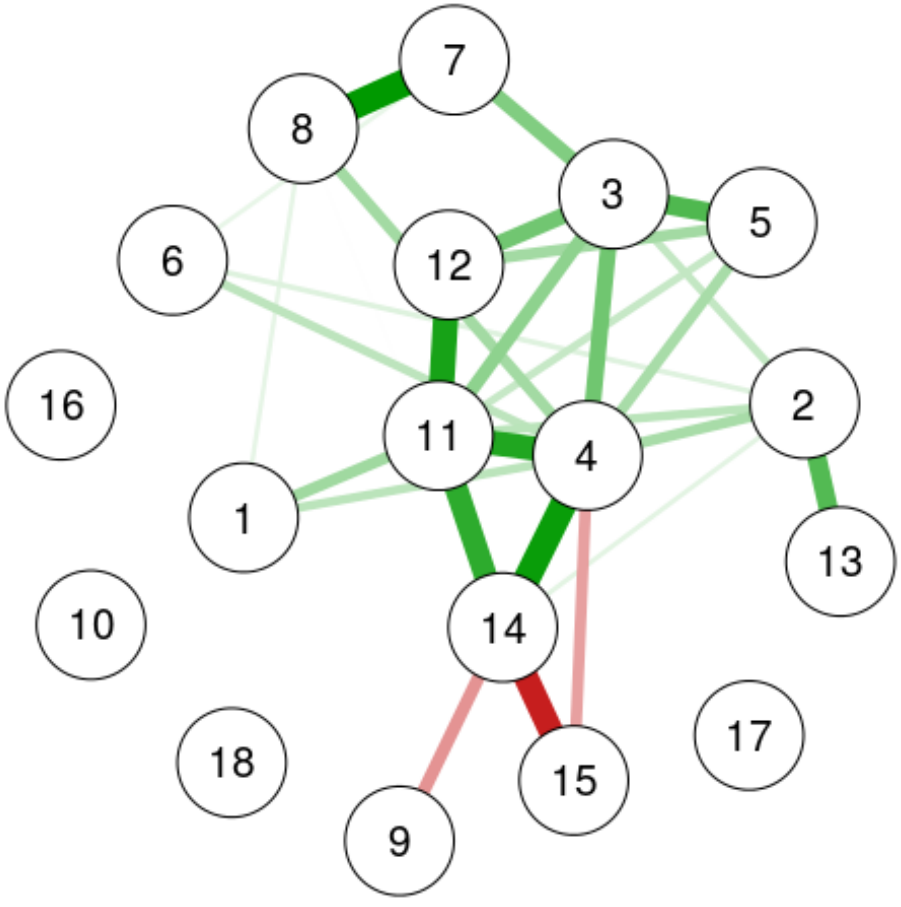
- Patient suffering from panic disorder and depressive symptoms
  - Perfectionist
- Measured over a period of two weeks
- Five times per day
- Items were chosen after intake together with therapist

Contemporaneous Network

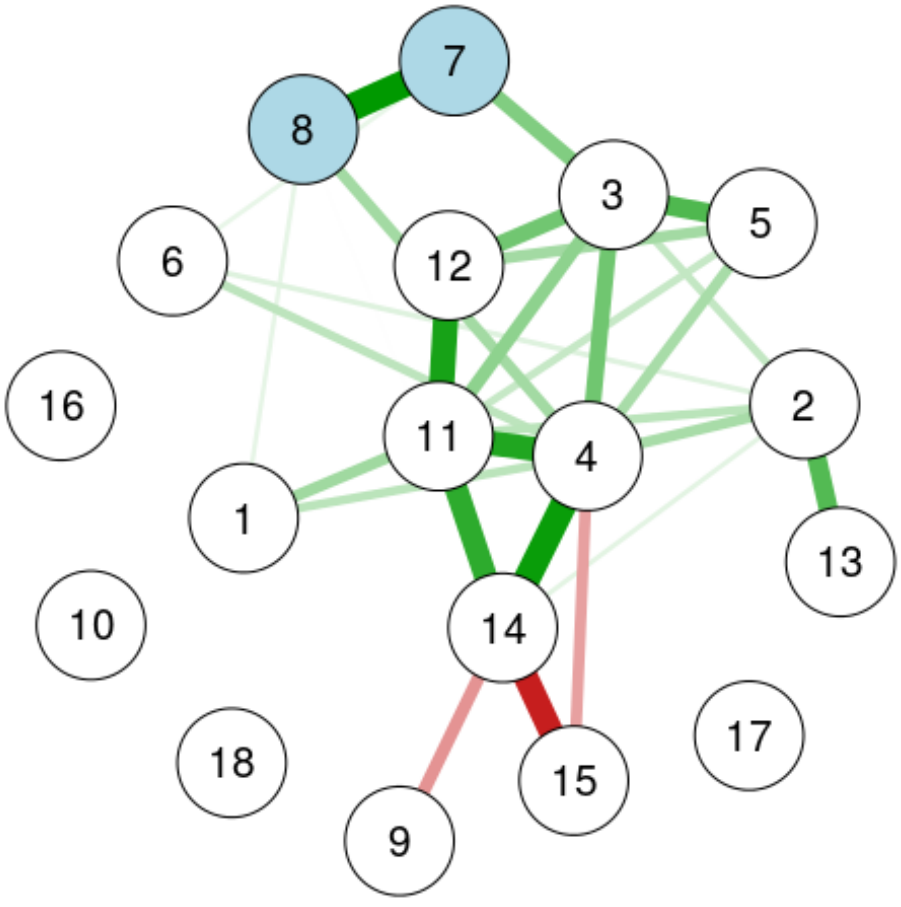


Temporal Network





1: I feel anxious
2: I feel stressed
3: I feel angry
4: I feel sad
5: I feel guilty
6: I feel weak
7: I feel worthless
8: I feel helpless
9: I feel full of Energy
10: I am afraid of a panic attack
11: I am afraid I am going to cry
12: I am afraid of appearing angry
13: I have 'had to do things'
14: I am experiencing bodily discomfort
15: I am enjoying myself
16: I let something pass I find important
17: I experienced my social environment as pleasurable
18: I was physically active



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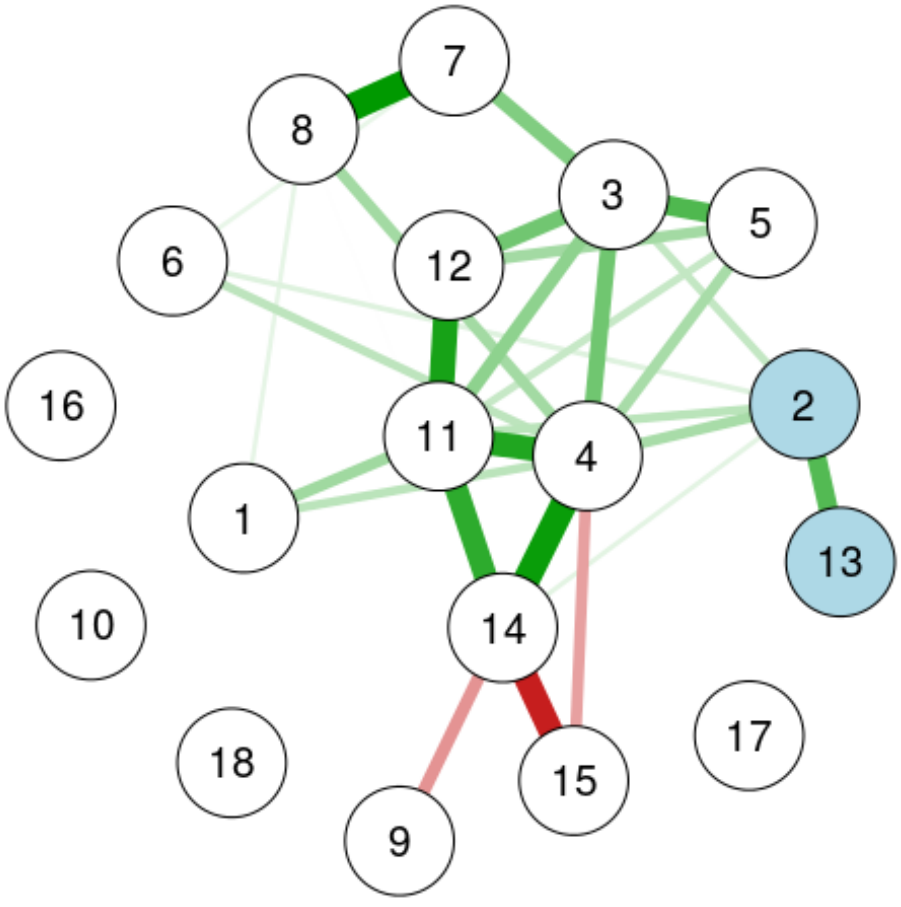
Feeling worthless interacts with feeling helpless



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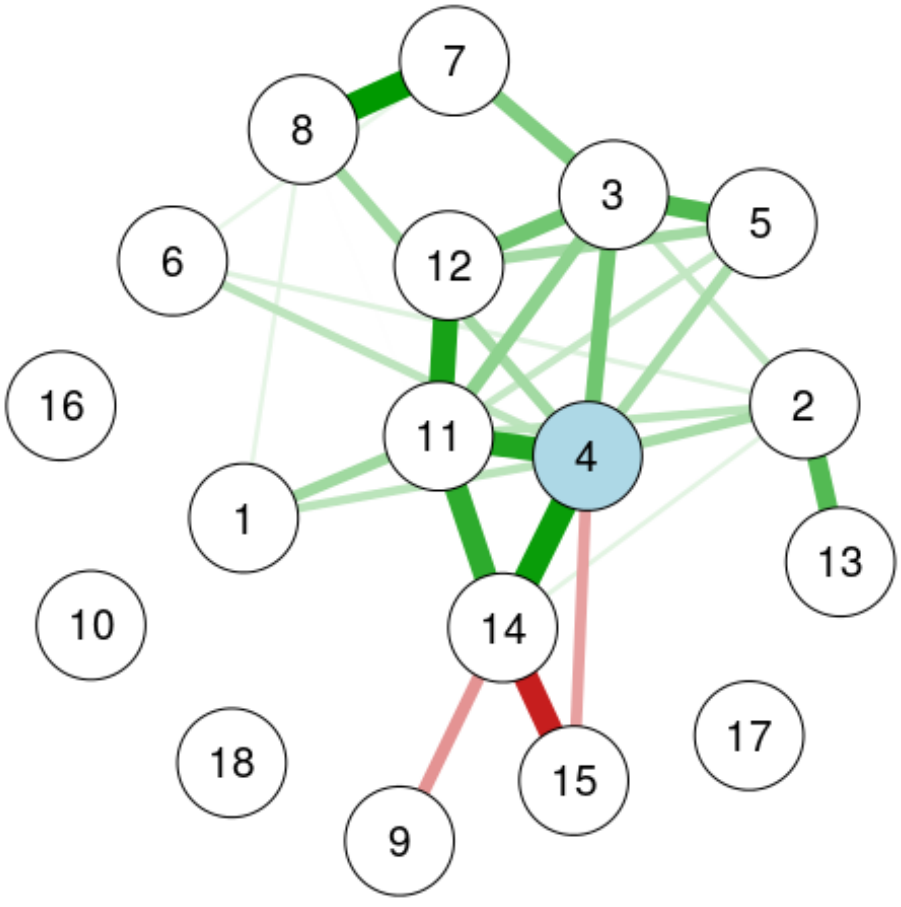
Feeling stressed interacts with feeling the need to do things



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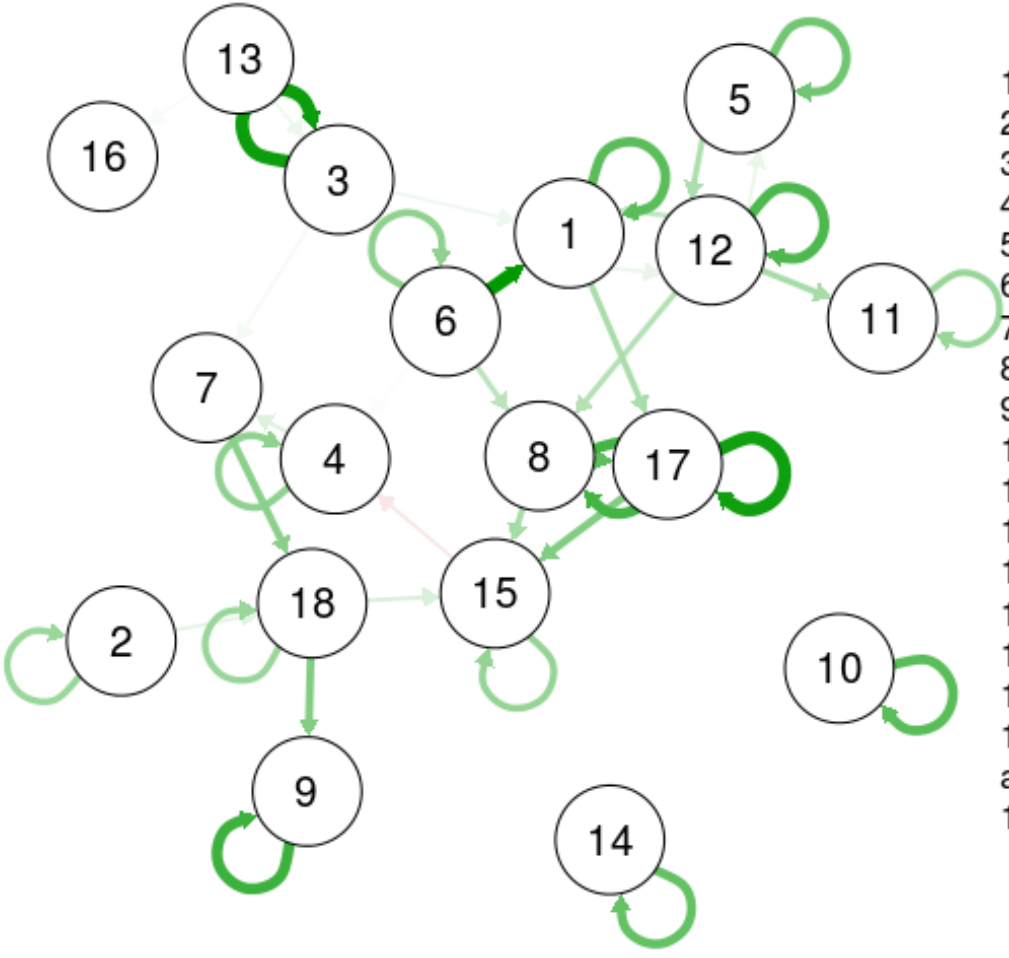
Central node: Feeling sad



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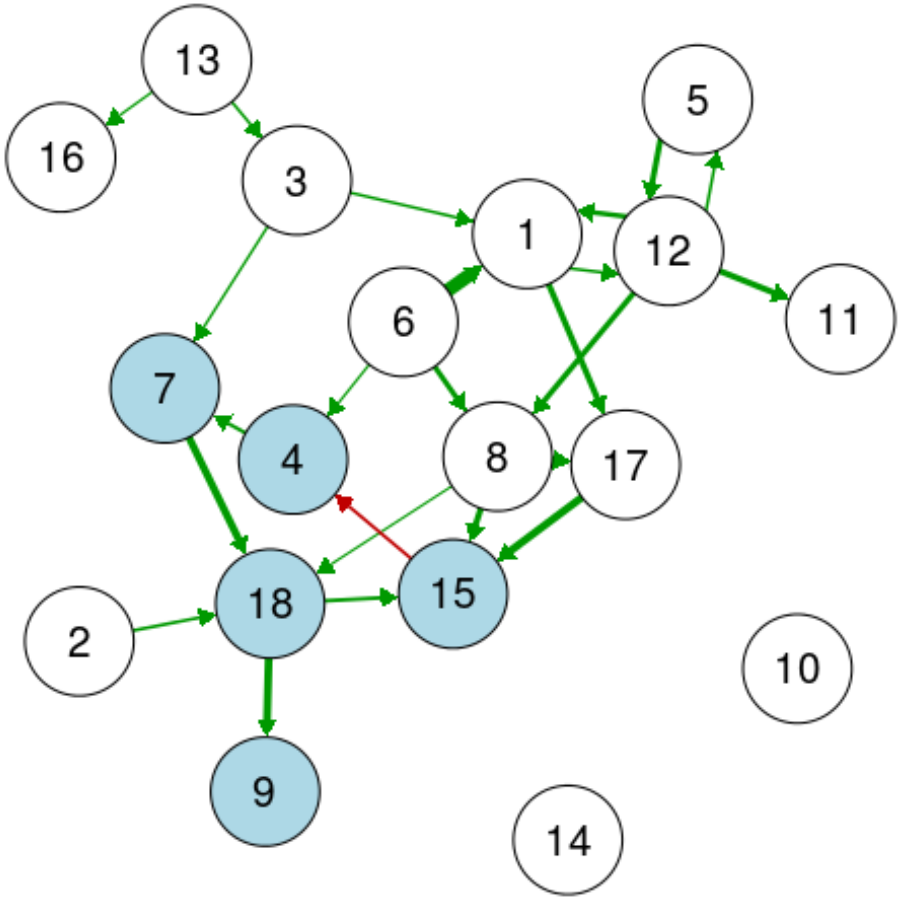
4: I feel sad
5: I feel guilty
6: I feel weak
7: I feel worthless
8: I feel helpless
9: I feel full of Energy
10: I am afraid of a panic attack
11: I am afraid I am going to cry
12: I am afraid of appearing angry
13: I have 'had to do things'
14: I am experiencing bodily discomfort
15: I am enjoying myself
16: I let something pass I find important
17: I experienced my social environment as pleasurable
18: I was physically active



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15: I am enjoying myself
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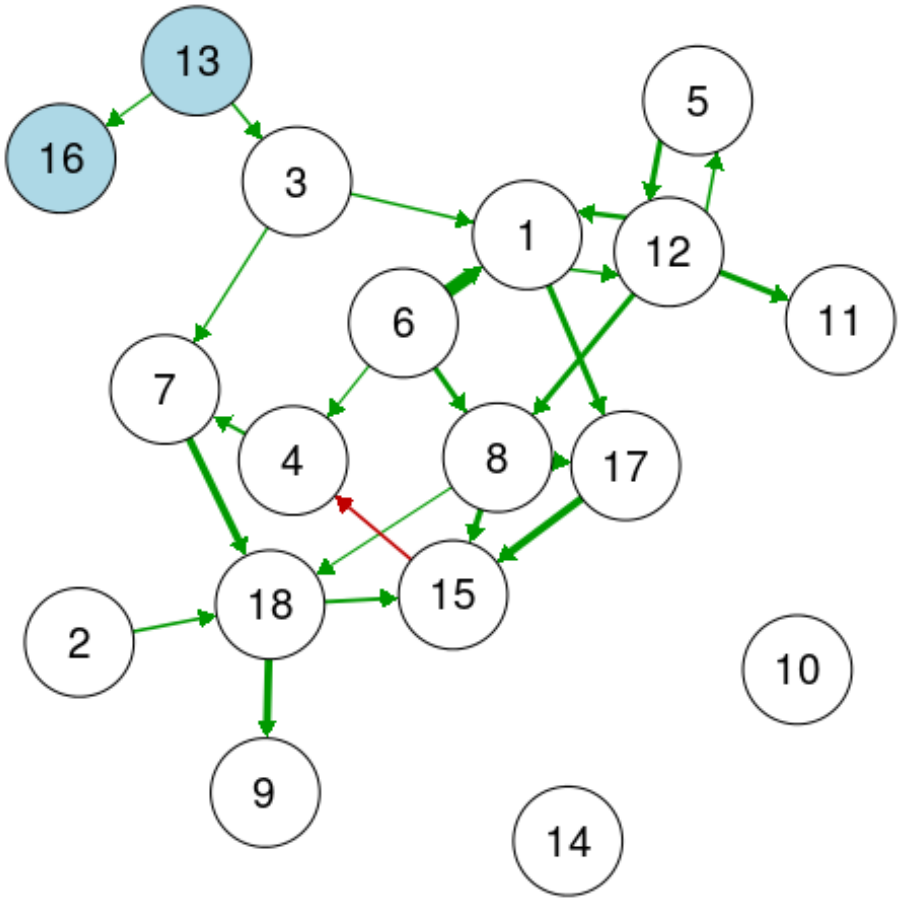
Cycle of enjoyment, feeling sad, feeling worthless and being active



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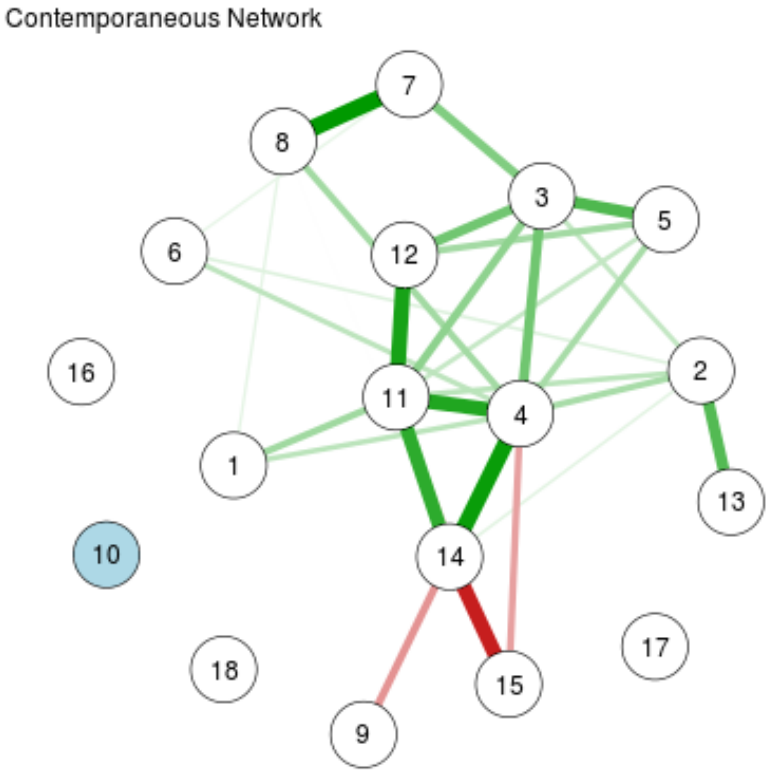
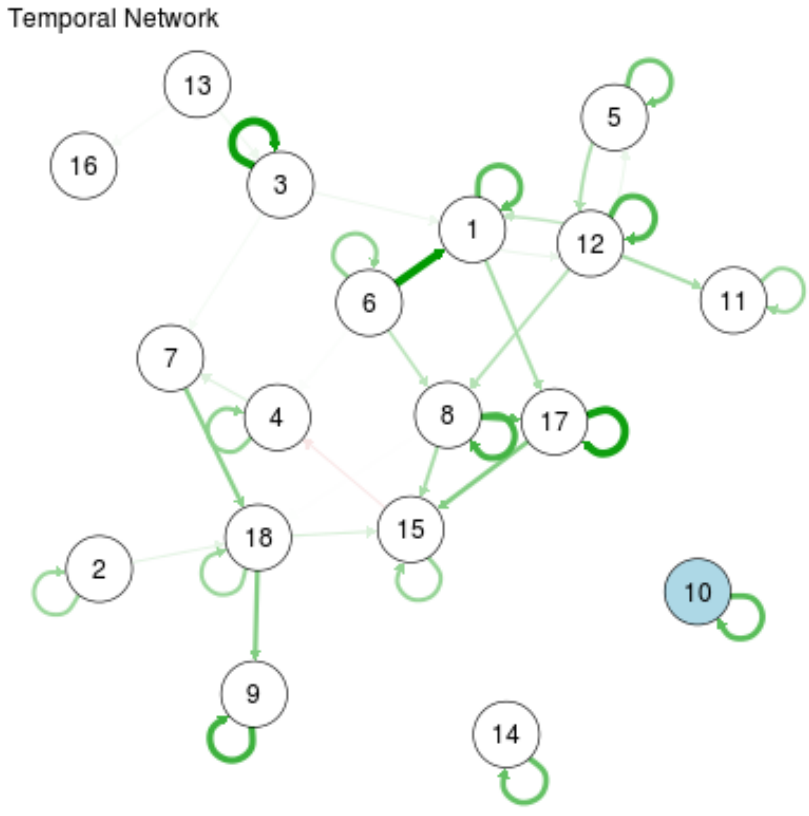
Having to had to do things leads to letting important things pass





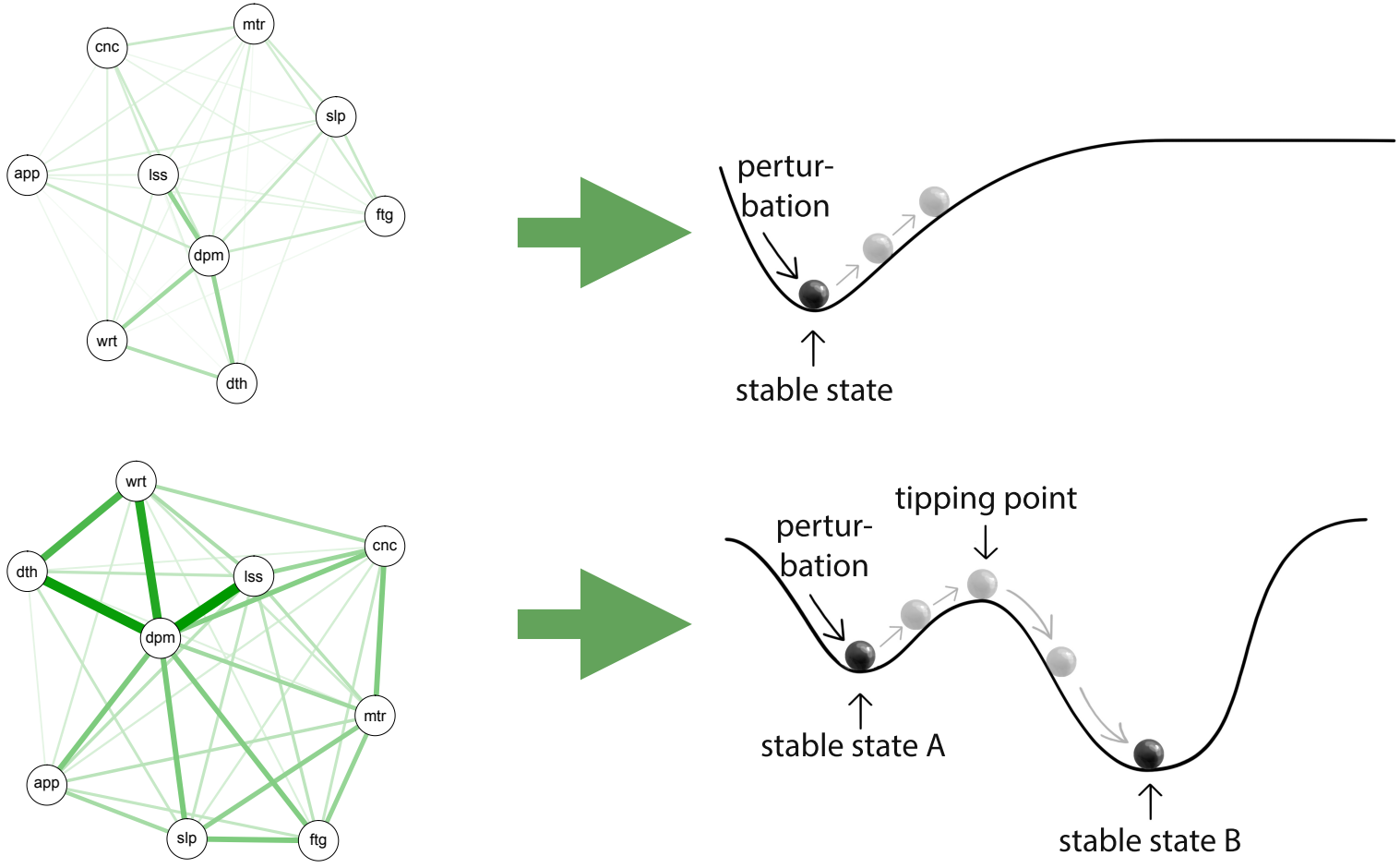
Fear of panic attack is not connected

Early Warning Signals

Early Warning Signals

Marieke Wichers

Marten Scheffer

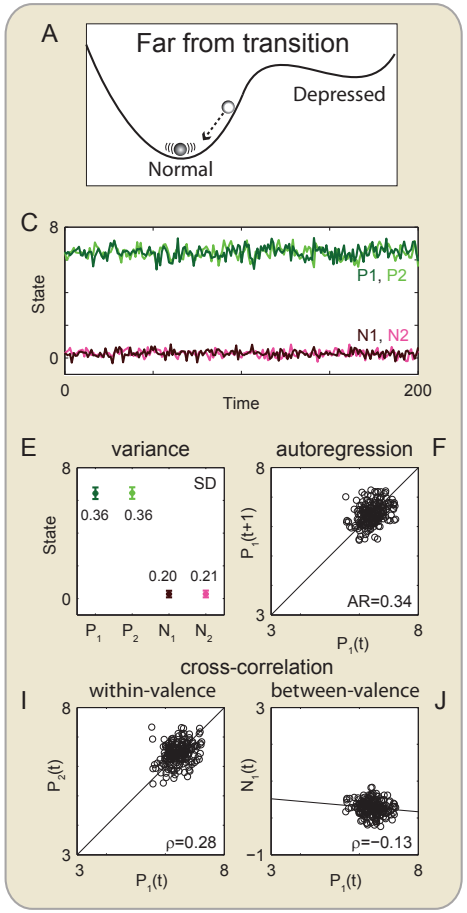


Strong connectivity yields sudden transitions to alternative attractors

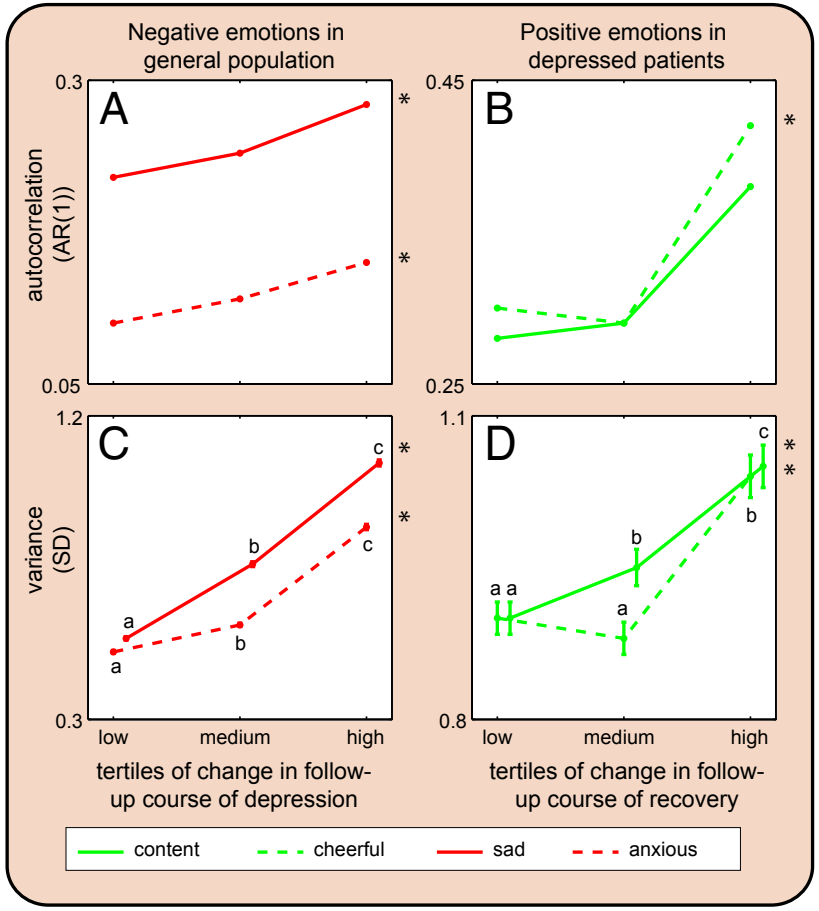
Critical slowing down

- In the neighborhood of a transition, complex systems “slow down”
- This means that their state at time t becomes a better predictor of their state at time $t + 1$ (“autoregression”)
- This means that individuals closer to a transition should slow down (have higher autoregression)
- We tested this hypothesis in two independent ESM datasets (one from Marieke Wichers in Maastricht, one from Peter Kuppens in Leuven)

Theory

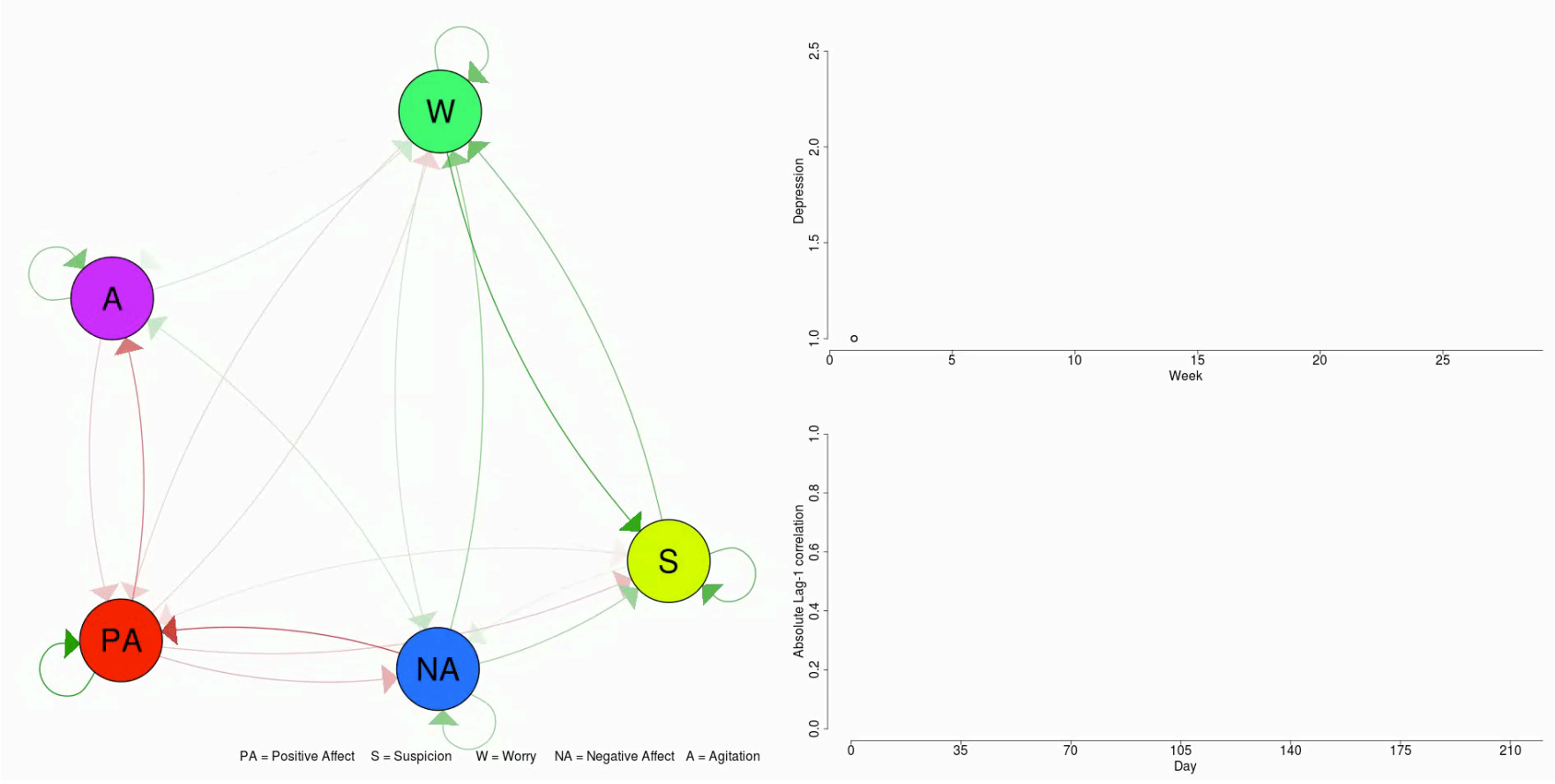


Data

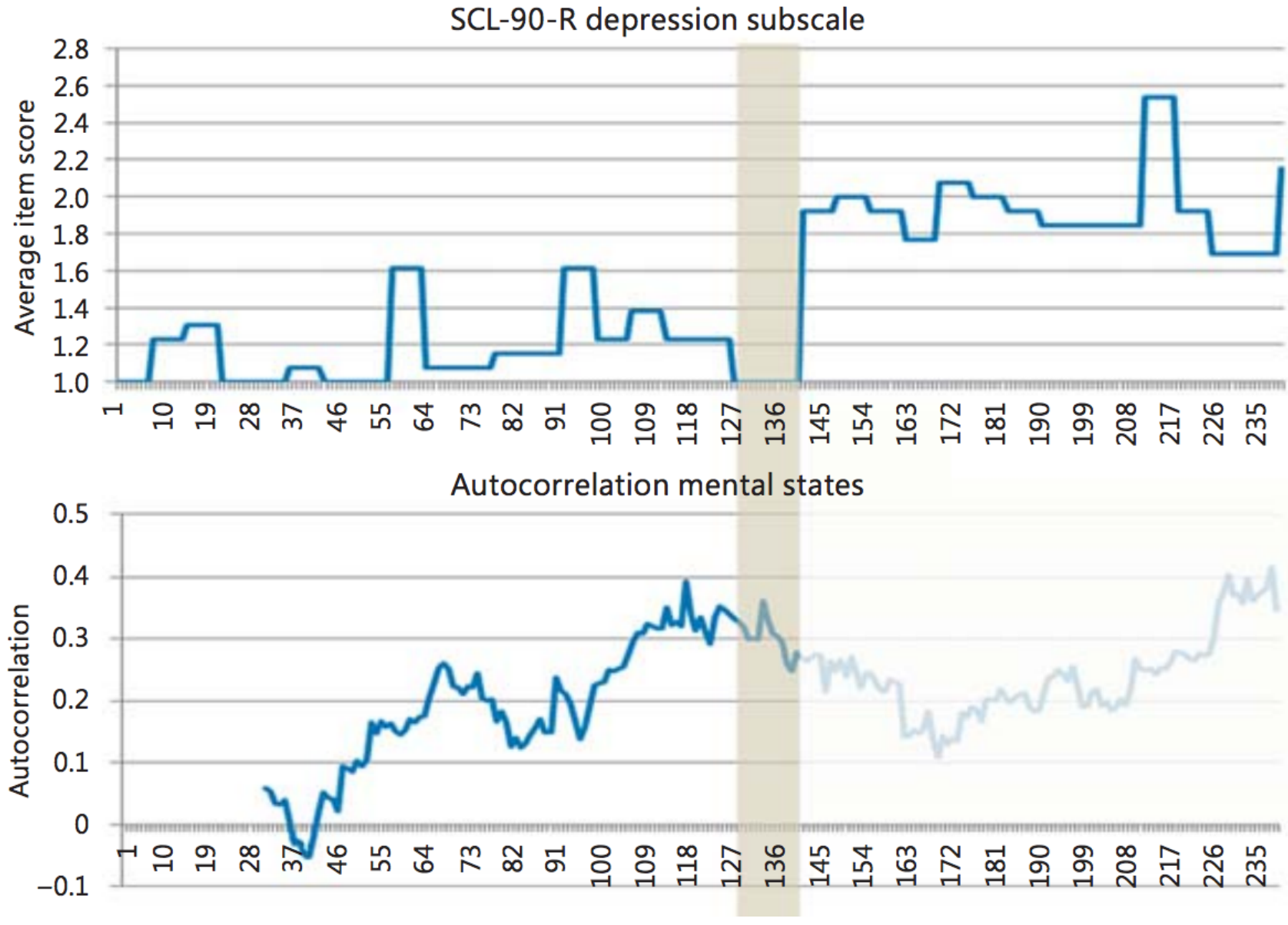


Van de Leemput et al., 2014, Proceedings of the National Academy of Sciences.

Intra-individual network change



Wichers et al., 2016, Psychotherapy and Psychosomatics.


SCL-90-R depression subscale
Average item score
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
1 10 19 28 37 46 55 64 73 82 91 100 109 118 127 136 145 154 163 172 181 190 199 208 217 226 235
Autocorrelation mental states
Autocorrelation
0.5
0.4
0.3
0.2
0.1
0
−0.1
1 10 19 28 37 46 55 64 73 82 91 100 109 118 127 136 145 154 163 172 181 190 199 208 217 226 235

General Understanding of Psychopathology

- More and more large-scale ESM studies of many subjects are being performed
- Sophisticated statistical techniques are being developed to handle such data
  - Multi-level Vector-autoregression
  - GIMME algorithm
- These studies give insight in individual differences in intra-individual dynamics

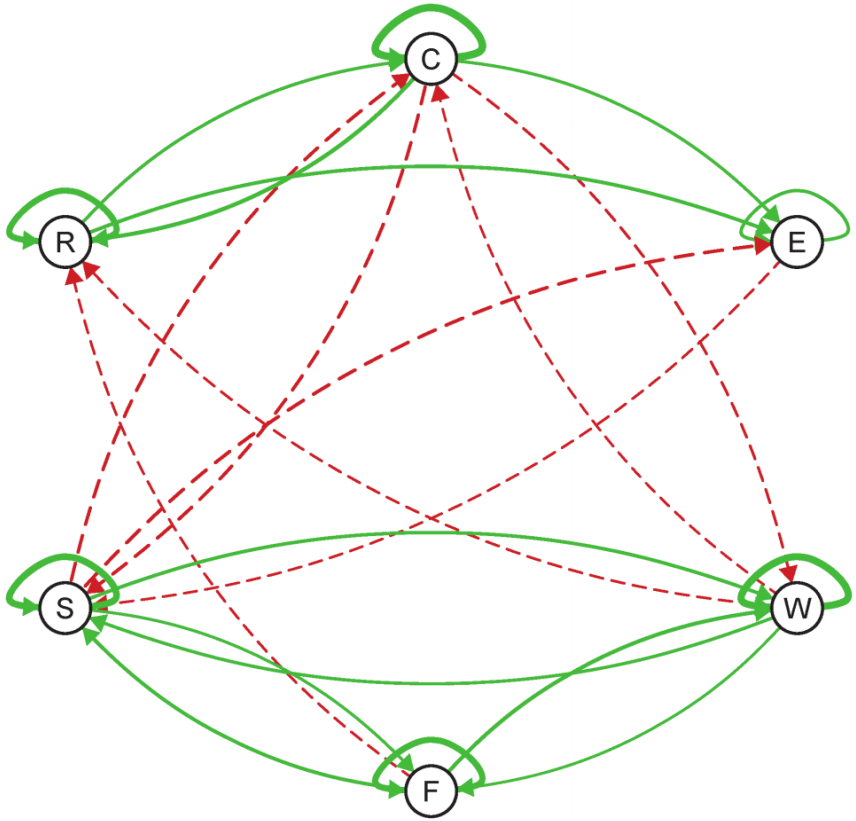


Figure 1. Estimated population network at baseline. The six items are: C = cheerful, E = pleasant event, W = worry, F = fearful, S = sad and R = relaxed. Solid green arrows correspond to positive connections and red dashed arrows to negative connections. Only arrows that surpass the significance threshold are shown (i.e., for which the p-value of the t-statistic is smaller than 0.05). Arrows can be either red, indicating a negative relationship (i.e., $\beta_{kj} < 0$), or green, indicating a positive relationship (i.e., $\beta_{kj} > 0$). Furthermore, the strength of the relation from item k to item j (i.e., an extremer value for β_{kj}) is translated into the thickness of the arrows: the thicker the arrow between two nodes, the stronger the nodes or items are related. Note that item responses can also be predicted from the previous state of the item itself. These arrows are the self-loops in the network.
doi:10.1371/journal.pone.0060188.g001

Bringmann, L. F., Vissers, N., Wichers, M., Geschwind, N., Kuppens, P., Peeters, F., ... & Tuerlinckx, F. (2013). A network approach to psychopathology: new insights into clinical longitudinal data. *PloS one, 8(4)*, e60188.

Brief Empirical Report

aps ASSOCIATION FOR PSYCHOLOGICAL SCIENCE

Clinical Psychological Science
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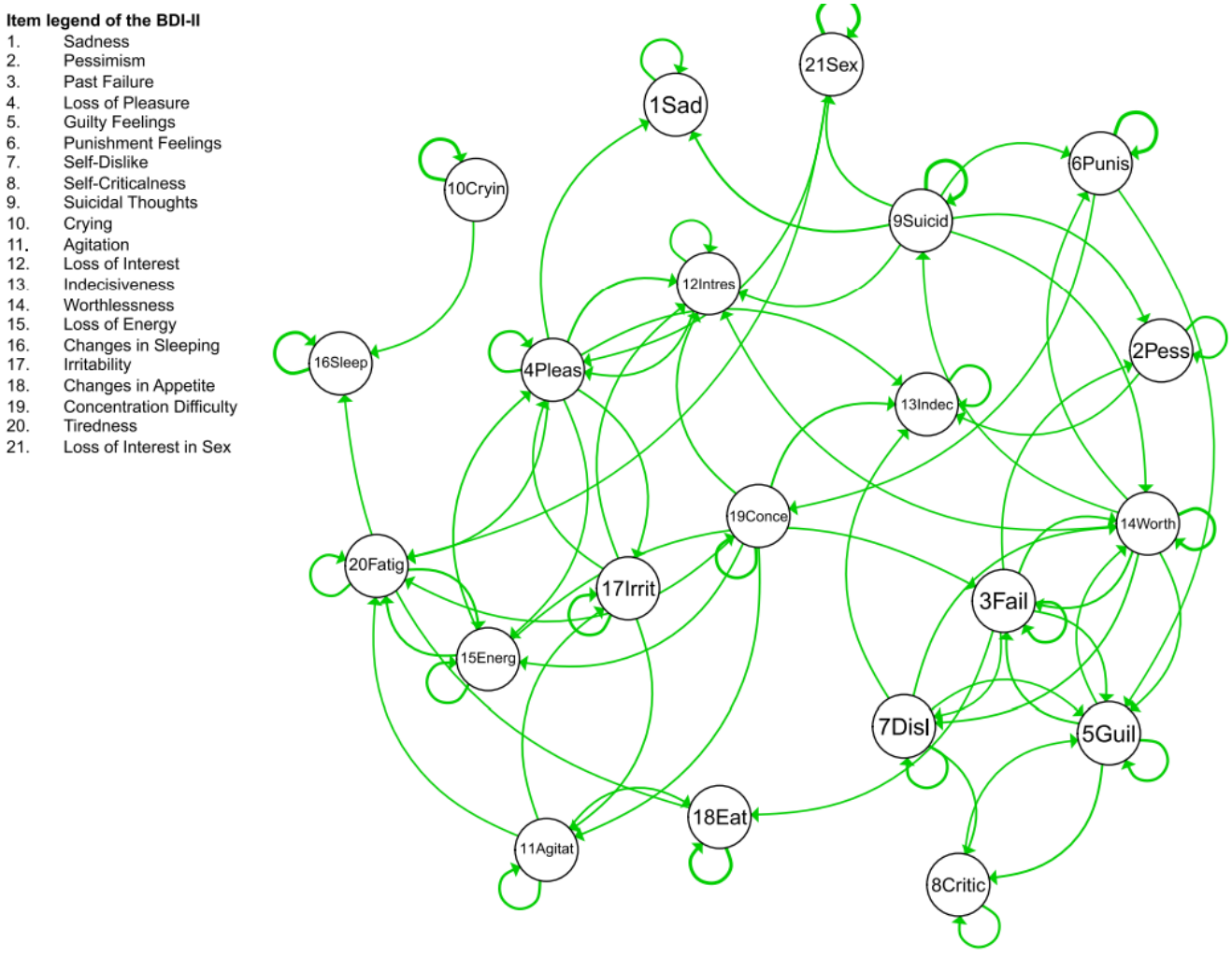
Emotion-Network Density in Major Depressive Disorder

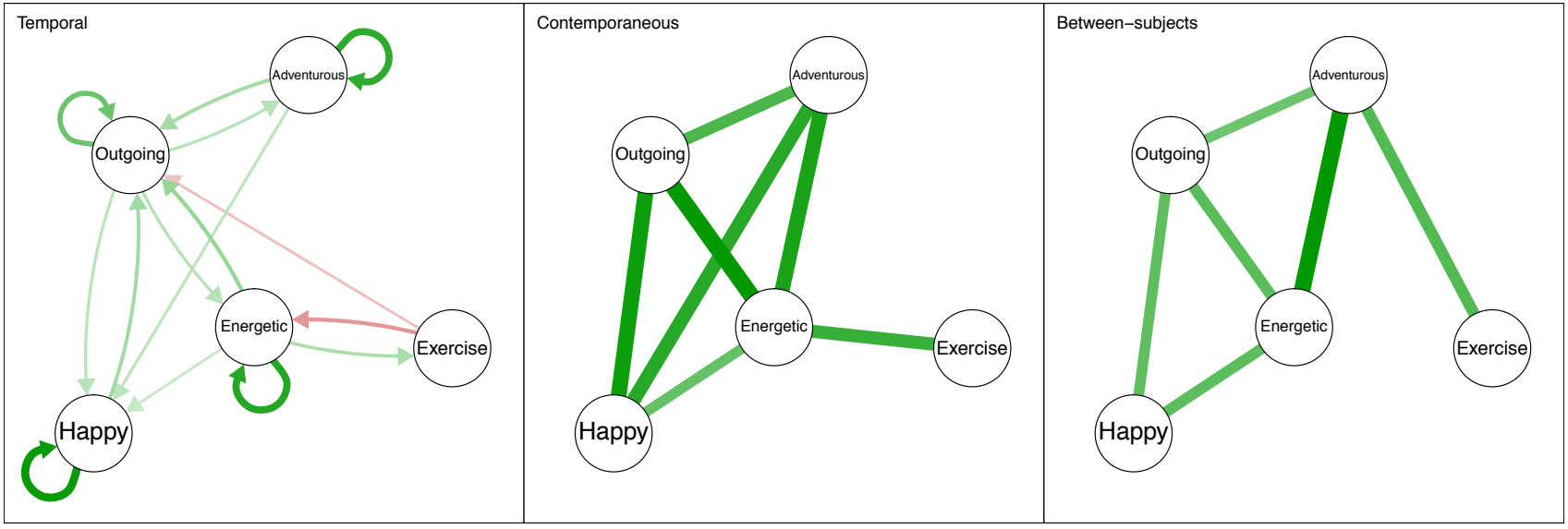
Madeline Lee Pe[1], Katharina Kircanski[2], Renee J. Thompson[3], Laura F. Bringmann[1], Francis Tuerlinckx[1], Merijn Mestdagh[1], Jutta Mata[4], Susanne M. Jaeggi[5], Martin Buschkuehl[6], John Jonides[7], Peter Kuppens[1], and Ian H. Gotlib[2]

[1]Department of Psychology, KU Leuven; [2]Department of Psychology, Stanford University; [3]Department of Psychology, Washington University in St. Louis; [4]Max Planck Institute for Human Development; [5]School of Education, University of California, Irvine; [6]MIND Research Institute, Irvine, California; and [7]Department of Psychology, University of Michigan, Ann Arbor



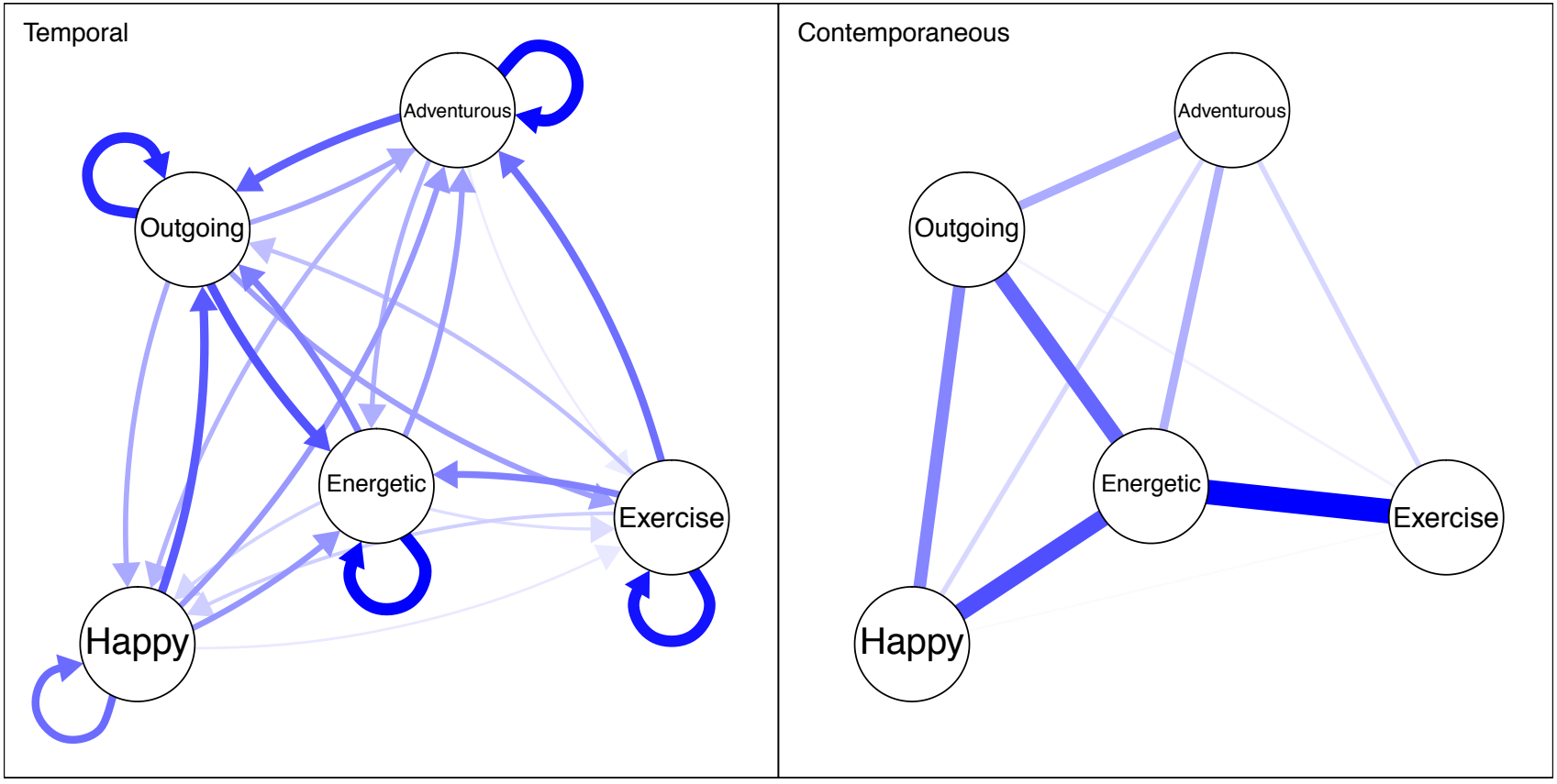
Bringmann, L.F., Lemmens, L.H.J.M., Huibers, M.J.H., Borsboom, D., and Tuerlinckx, F. (2015). Revealing the dynamic network structure of the Beck Depression Inventory-II. *Psychological Medicine 45*, 747–757.

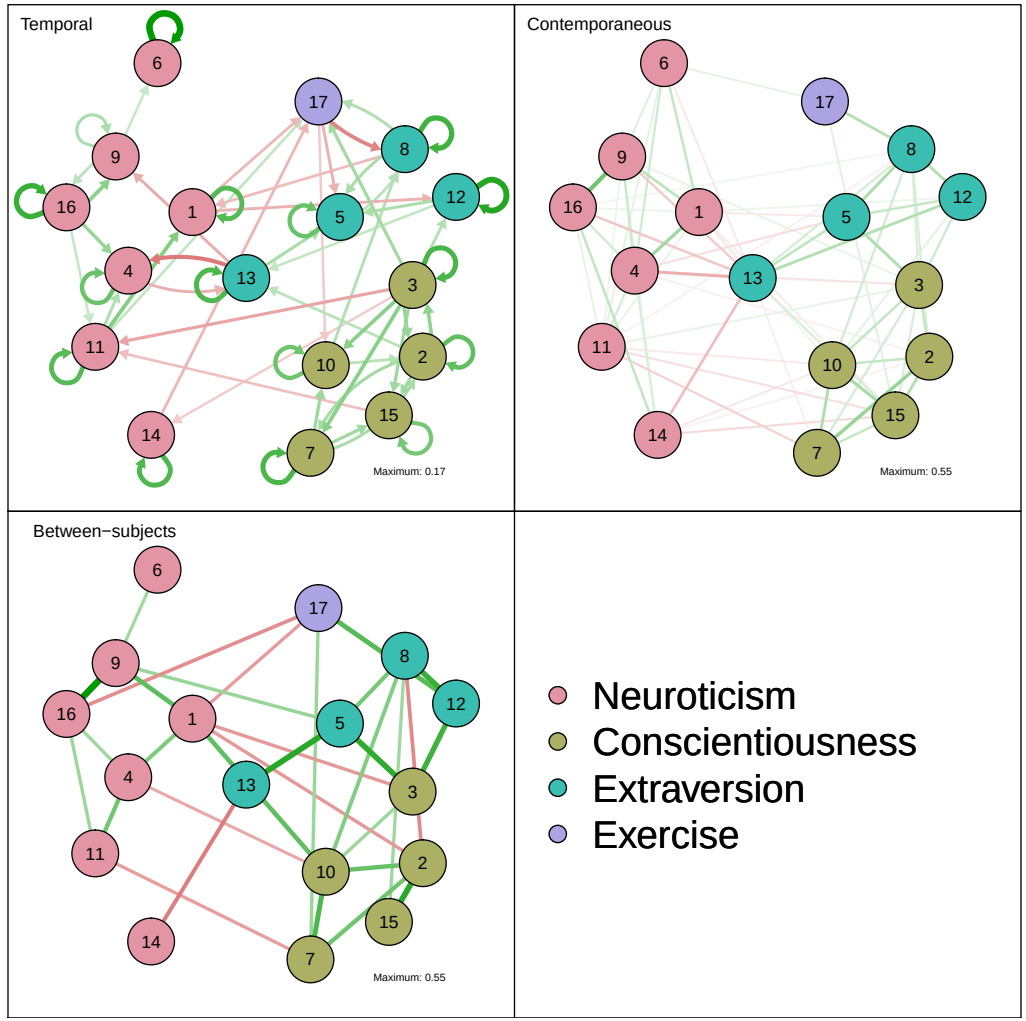
Novel Extensions



- Between-subjects network: concentration network between stationary means
- Two-step multilevel VAR

Individual Differences





1 = “Worried”; 2 = “Organized”; 3 = “Ambitious”; 4 = “Depressed”; 5 = “Outgoing”; 6 = “Self-Conscious”; 7 = “Self-Disciplined”; 8 = “Energetic”; 9 = “Frustrated”; 10 = “Focused”; 11 = “Guilty”; 12 = “Adventurous”; 13 = “Happy”; 14 = “Control”; 15 = “Achieved”; 16 = “Angry”; 17 = “Exercise.”

arXiv.org > stat > arXiv:1609.04156

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Statistics > Methodology

Discovering Psychological Dynamics in Time-Series Data

Sacha Epskamp, Lourens J. Waldorp, René Mõttus, Denny Borsboom

(Submitted on 14 Sep 2016)

This paper provides a methodological overview of statistical network models in cross-sectional and time-series data. The increasing trend of modeling psychological data through networks attempts to highlight potential causal relationships between observed variables. When data are cross-sectional, it is becoming increasingly popular to estimate a Gaussian graphical model (GGM; a network of partial correlation coefficients). In a time-series analysis, networks are typically constructed through the use of (multilevel) vector autoregression (VAR). VAR estimates a directed network that encodes temporal predictive effects - the temporal network. We show that GGM and VAR models are closely related: VAR generalizes the GGM by taking violations of independence between consecutive cases into account. VAR analyses can also return a GGM that encodes relationships within the same window of measurement - the contemporaneous network, which has not yet been extensively utilized in the literature. When multiple subjects are measured, multilevel VAR estimates fixed and random temporal networks. Proper centering can disentangle within- and between-subject variance in such processes. We show, for the first time, that the between-subject effects can be summarized in a GGM network - the between-subjects network. We argue that such between-subjects effects can also indicate causal pathways. Furthermore, we propose a novel two-step, multilevel estimation procedure to obtain fixed and random effects for contemporaneous network structures. We have implemented this procedure in the R package mlVAR. We present a simulation study to show the performance of mlVAR and to showcase the method in an empirical example on personality inventory items and physical exercise.

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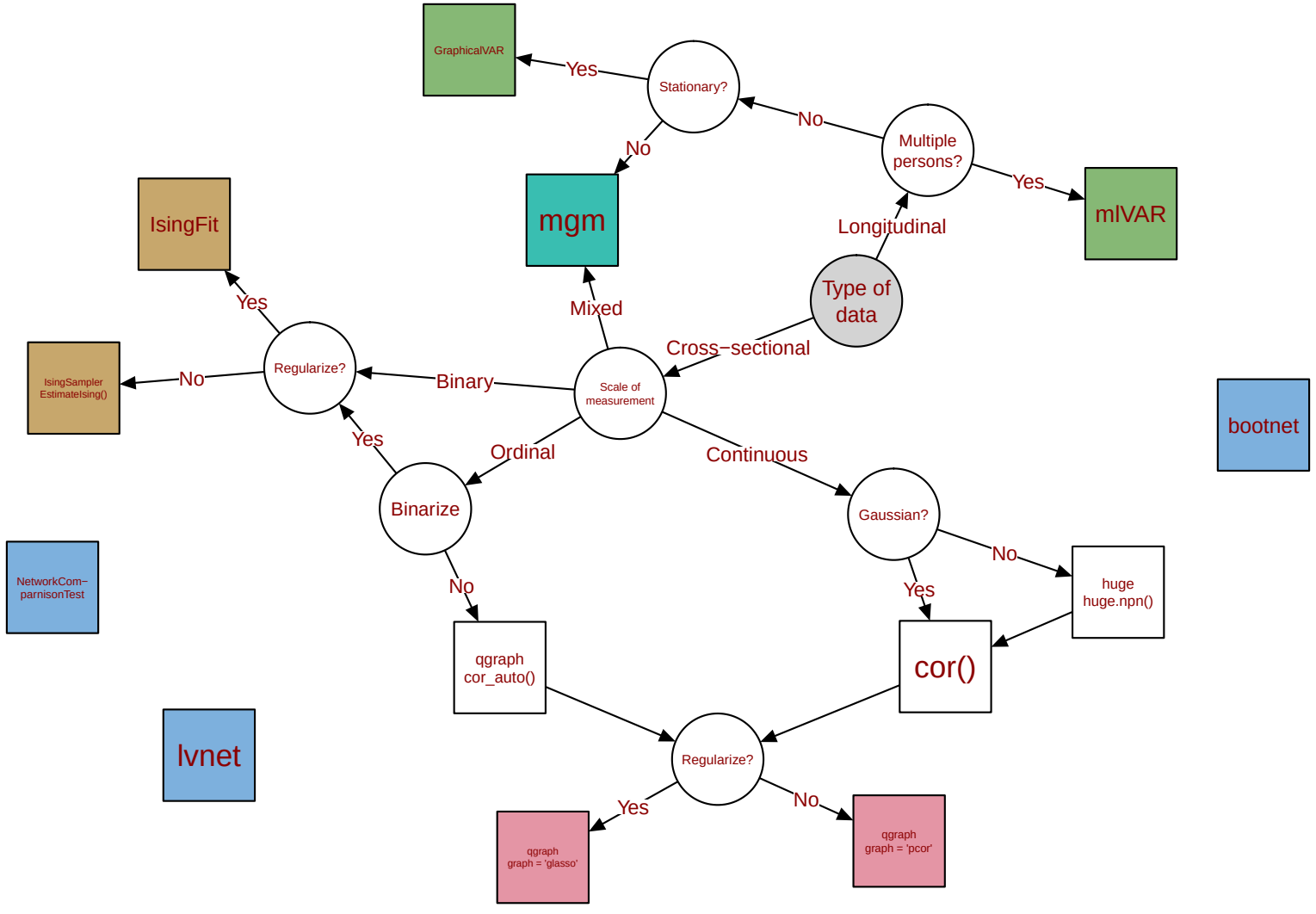
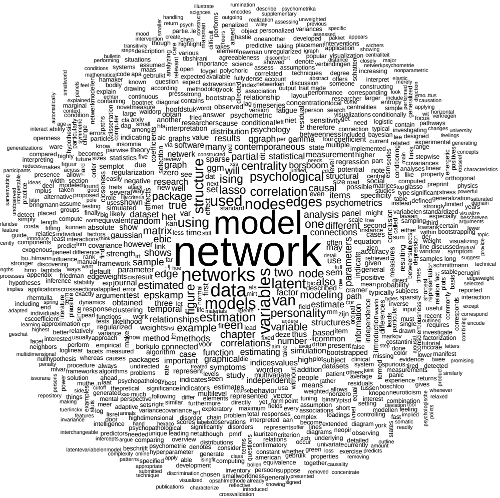
Conclusion

Discussion

- Network approach is a new way of looking at the relation between disorders and symptoms
- It's combination with time-series analysis provides a promising new approach to treatment intervention selection and monitoring
- However, still in its infancy: do not overestimate the possibilities
- Probably the best option is to combine statistics with common sense and introspective reports

The Psychosystems Ecosystem





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