

Understanding Psychopathology as Complex Networks

Jonas Haslbeck

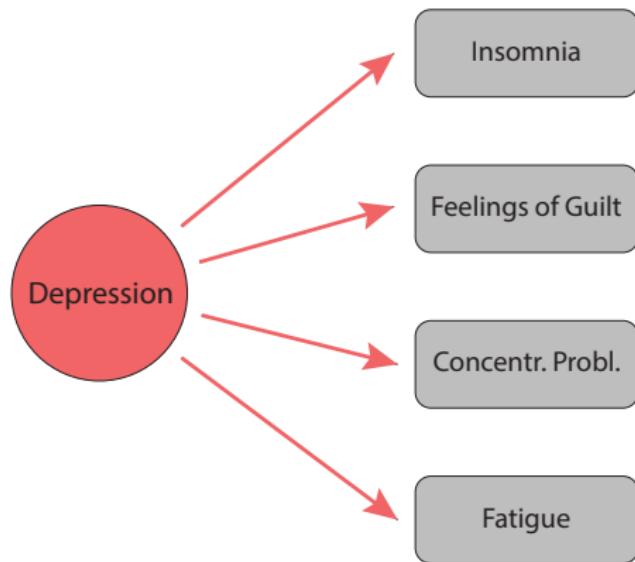
University of Amsterdam

30th EFPSA Congress; Vilmeiro, Portugal

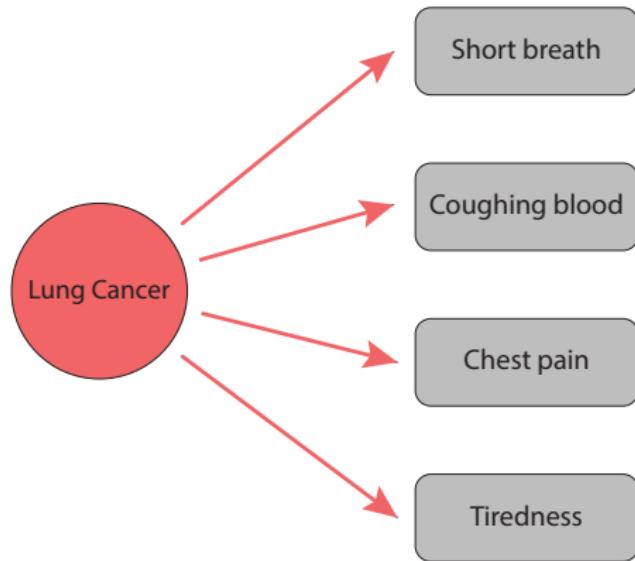
Overview

1. The traditional view on psychopathology
2. Psychopathology as complex networks
3. The within-between issue
4. N=1 models

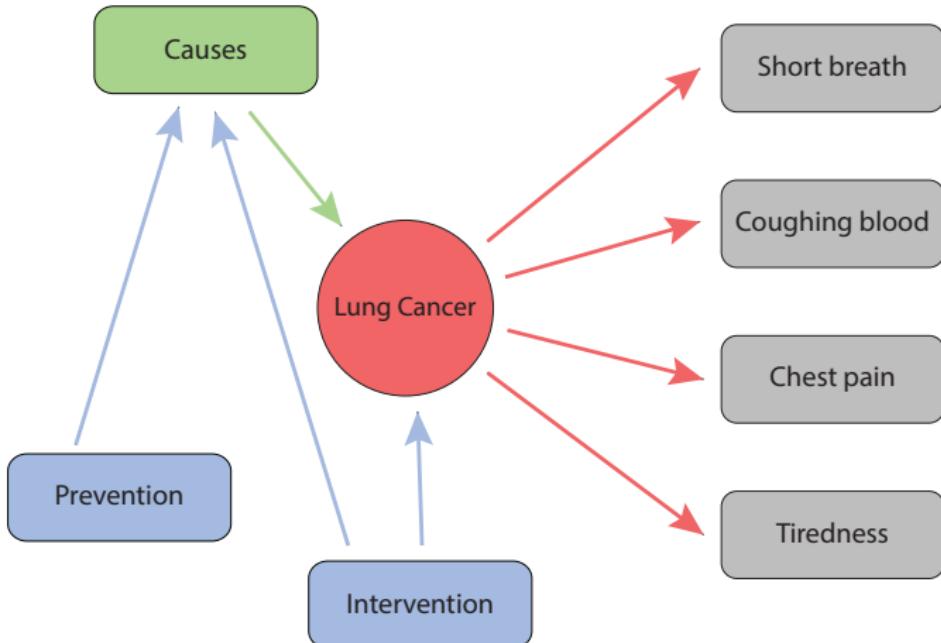
'Traditional' Model of Psychopathology



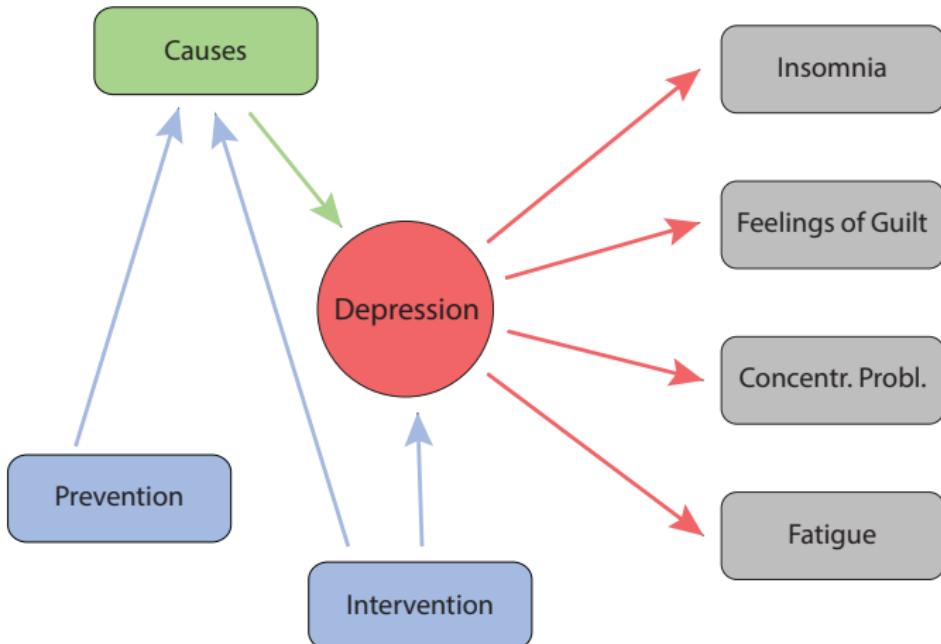
Model of (medical) Pathology



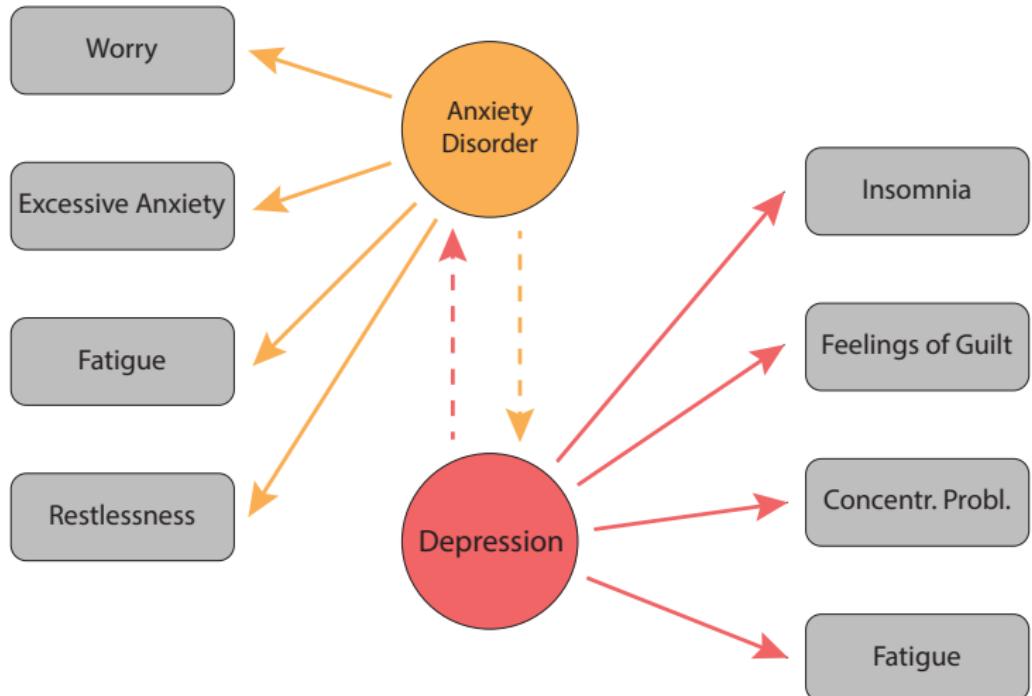
Model of (medical) Pathology



'Traditional' Psychopathology



Explaining Comorbidity



Depression & Genetics



- ▶ Goal: Find differences between genomes of depressed/healthy group
- ▶ But: No success! (see e.g. Hek et al., 2013; Lewis et al., 2010; Shi et al 2011; Wray et al 2012)

Depression & Neuroscience

OPEN

Molecular Psychiatry (2015), 1–7
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ORIGINAL ARTICLE

Subcortical brain alterations in major depressive disorder: findings from the ENIGMA Major Depressive Disorder working group

L Schmaal¹, DJ Veltman¹, TGM van Erp², PG Sämann³, T Frodl^{4,5}, N Jahanshad⁶, E Loehr⁷, H Tiemeier^{7,8}, A Hofman⁷, WJ Niessen^{9,10}, MW Vernooy^{7,9}, MA Ikram^{7,9,11}, K Wittfeld¹², HJ Grabe^{12,13,14}, A Block¹⁵, K Hegenscheid¹⁵, H Volzke¹⁶, D Hoehn¹⁷, M Czisch¹⁷, J Lagopoulos¹⁷, SN Hatton¹⁷, IB Hickie¹⁷, R Goya-Maldonado¹⁸, B Krämer¹⁸, O Gruber¹⁸, B Couvy-Duchesne^{19,20,21}, ME Rentera²², LT Strike^{19,20,21}, NT Mills^{22,23}, GI de Zubiracay²⁰, KL McMahon²¹, SE Medland²⁴, NG Martin²², NA Gillespie²⁵, MJ Wright¹⁹, GB Hall²⁶, GM MacQueen²⁷, EM Frey⁴, A Carvalledo²⁸, LS van Velzen¹, MJ van Tol²⁹, NJ van der Wee^{30,31}, IM Veer³², H Walter³³, K Schnell³³, E Schramm³⁴, C Normann³⁴, D Schoepf³⁵, C Konrad³⁶, B Zurowski³⁷, T Nickson³⁸, AM McIntosh^{38,39}, M Papmeyer³⁸, HC Whalley³⁸, JE Sussmann³⁸, BR Godlewski⁴⁰, PJ Cowen⁴⁰, FH Fischer^{41,42}, M Rose^{41,43}, BWJH Penninx¹, PM Thompson⁶ and DP Hibar⁶ for the ENIGMA-Major Depressive Disorder Working Group⁴⁴

- ▶ 1728 MD patients, 7199 controls, 9 subcortical regions

Findings:

- ▶ Continuous: no region associated with MD severity
- ▶ Categorical: hippocampal volume 1.4 % smaller for MD patients

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- ▶ 1728 MD patients, 7199 controls, 9 subcortical regions

But:

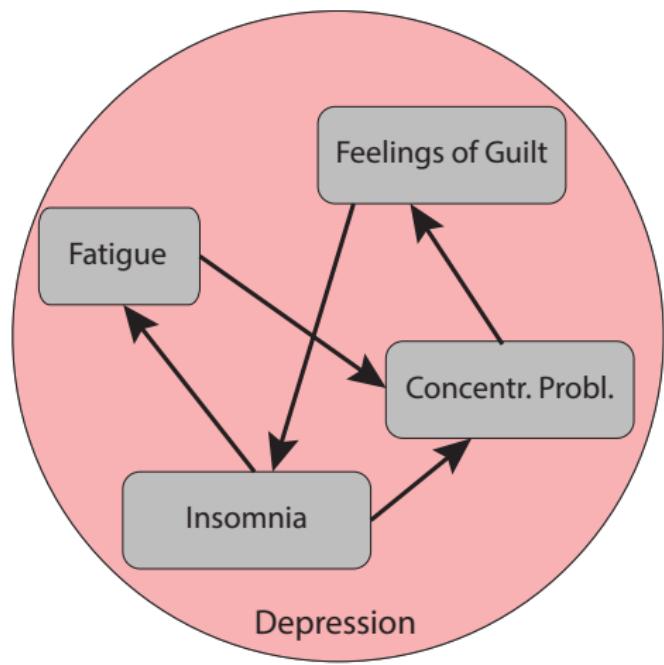
- ▶ smaller hippocampal volume in schizophrenia, PTSD, chronic alcoholism, epilepsy, ..., lack of exercise and activity

Summary: 'Traditional' Psychopathology

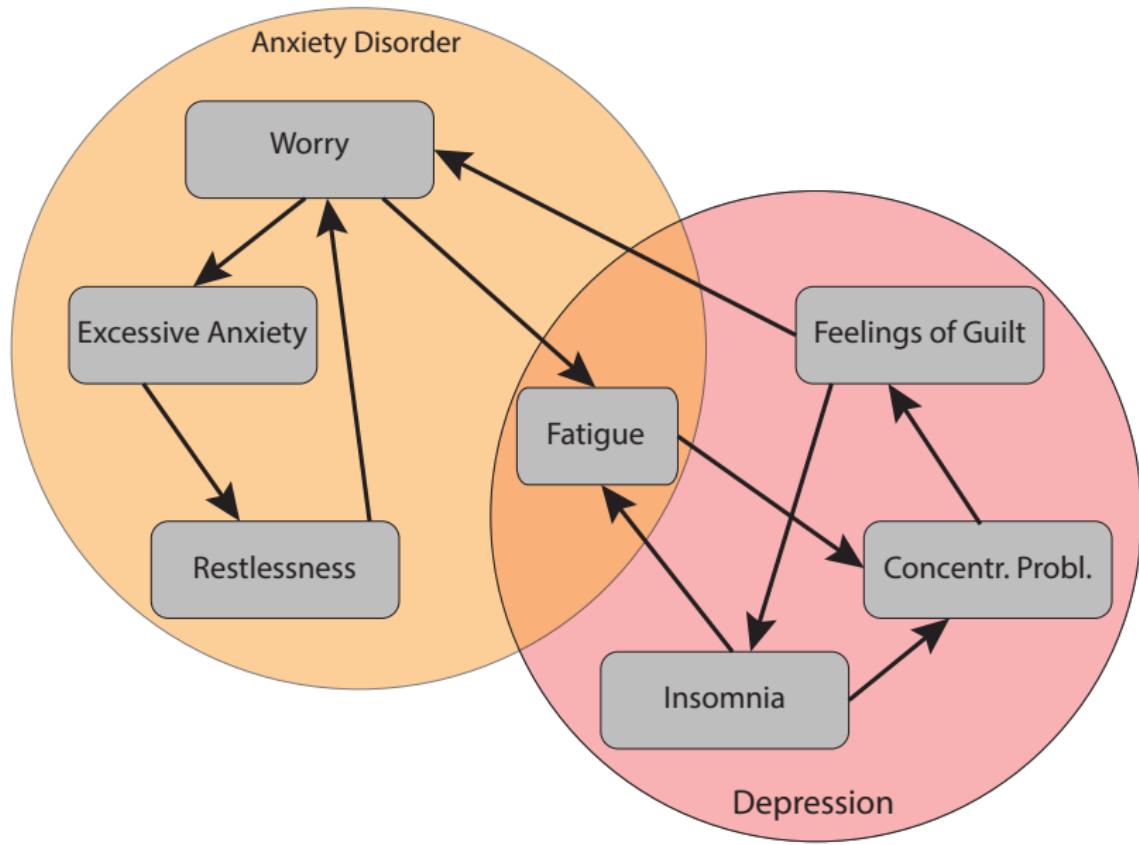
Problems:

- ▶ We cannot identify the disorder independently of the symptoms
- ▶ No progress in Neuroscience
- ▶ No progress in Genetics
- ▶ Problematic conceptualization of comorbidity

Psychopathology as Complex Networks

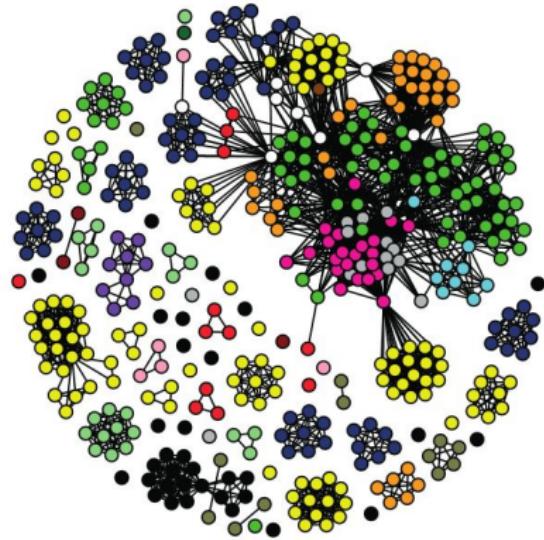


Comorbidity as Complex Networks



Networks of Classification Systems (DSM-4)

- Disorders of infancy, childhood, and adolescence
- Delirium, dementia, and other cognitive disorders
- Mental disorders due to a medical condition
- Substance-related disorders
- Schizophrenia and other psychotic disorders
- Mood disorders
- Anxiety disorders
- Somatoform disorders
- Factitious disorders
- Dissociative disorders
- Sexual and gender identity disorders
- Eating disorders
- Sleep disorders
- Habit and impulse disorders
- Adjustment disorders
- Personality disorders
- Enduring personality change
- Symptom is featured equally in multiple classes



(Borsboom, et al. 2011)

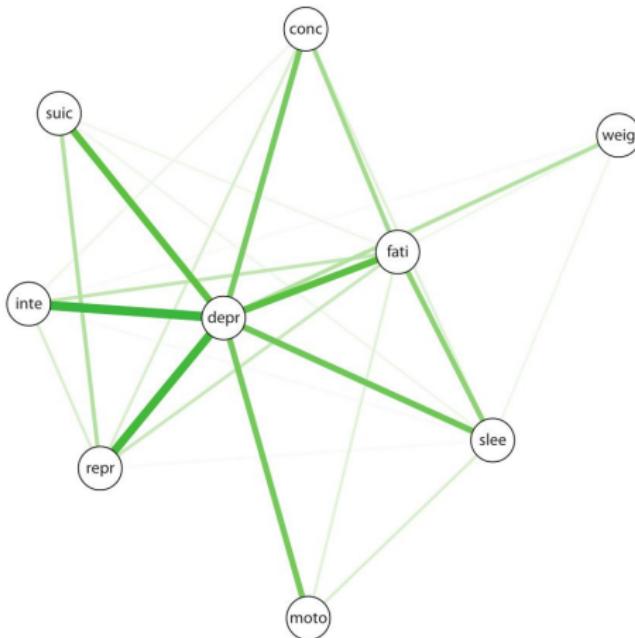
Networks from Classification Systems (ICD-10)



- Disorders of infancy, childhood, and adolescence
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- Mental disorders due to a medical condition
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- Schizophrenia and other psychotic disorders
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- Adjustment disorders
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- Enduring personality change
- Symptom is featured equally in multiple classes

(Tio, et al. 2016)

Networks from Expert Ratings



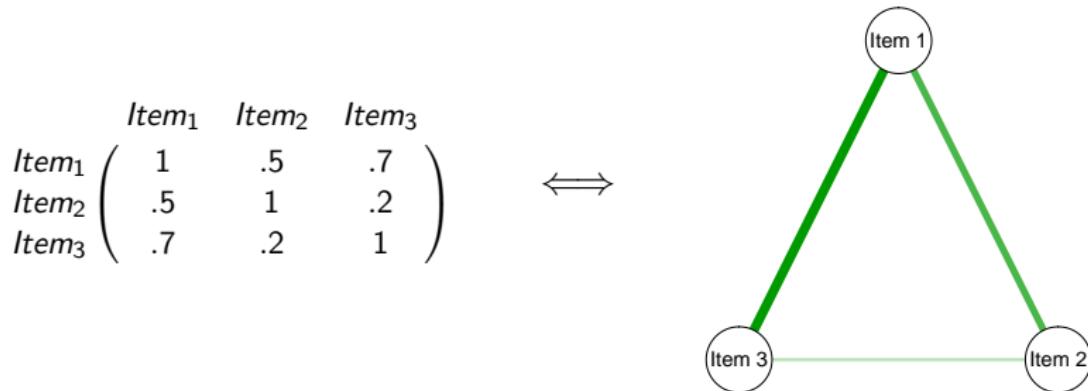
Rating by 14 Dutch Clinicians: Co-occurrence of symptoms
(Borsboom et al., 2013)

Networks from Data

$$\begin{array}{c} \begin{array}{ccc} & Item_1 & Item_2 & Item_3 \\ Person_1 & \begin{pmatrix} 1 & 2 & 0 \\ 3 & 5 & 2 \\ \vdots & \vdots & \vdots \\ Person_N & \begin{pmatrix} 4 & 4 & 6 \end{pmatrix} \end{array} & \iff & \begin{array}{ccc} & Item_1 & Item_2 & Item_3 \\ Item_1 & \begin{pmatrix} 1 & .5 & .7 \\ Item_2 & .5 & 1 & .2 \\ Item_3 & .7 & .2 & 1 \end{pmatrix} \end{array} \end{array} \\ \text{Data} \qquad \qquad \qquad \text{Correlation Matrix} \end{array}$$

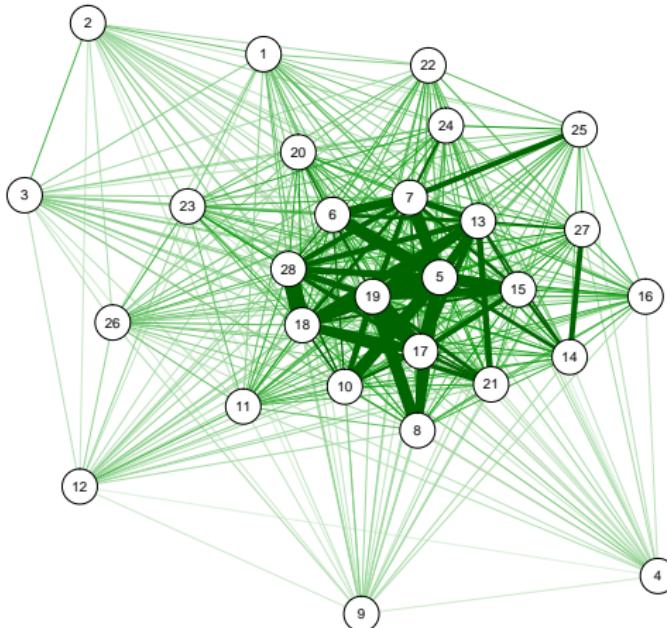
Correlation matrix of symptoms!

Networks from Data



Visualize Correlation Matrix as a Network!

Correlation Network

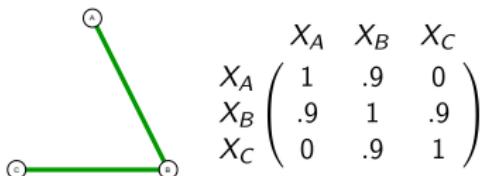


- 1: Falling Asleep
 - 2: Sleep During the Night
 - 3: Waking Up Too Early
 - 4: Sleeping Too Much
 - 5: Feeling Sad
 - 6: Feeling Irritable
 - 7: Feeling Anxious or Tense
 - 8: Response of Mood to Good Events
 - 9: Mood in Relation of Time of Day
 - 10: The Quality of Mood
 - 11: Change in Appetite
 - 12: Weightchange
 - 13: Concentration
 - 14: View of Myself
 - 15: View of my Future
 - 16: Thoughts of Death and Suicide
 - 17: General Interest
 - 18: Energy Level
 - 19: Capacity for Pleasure
 - 20: Interest in Sex
 - 21: Feeling slowed down
 - 22: Feeling restless
 - 23: Aches and pains
 - 24: Other bodily symptoms
 - 25: Panic/Phobic symptoms
 - 26: Constipation/diarrhea
 - 27: Interpersonal Sensitivity
 - 28: Leader Paralysis/Physical Energy

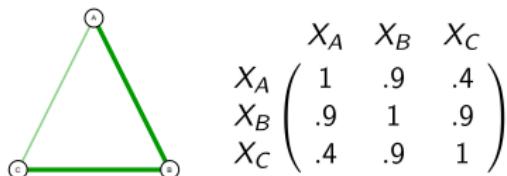
Responses of 2460 individuals to Beck's Depression Inventory

The Problem of spurious correlations

True model



Correlation Matrix



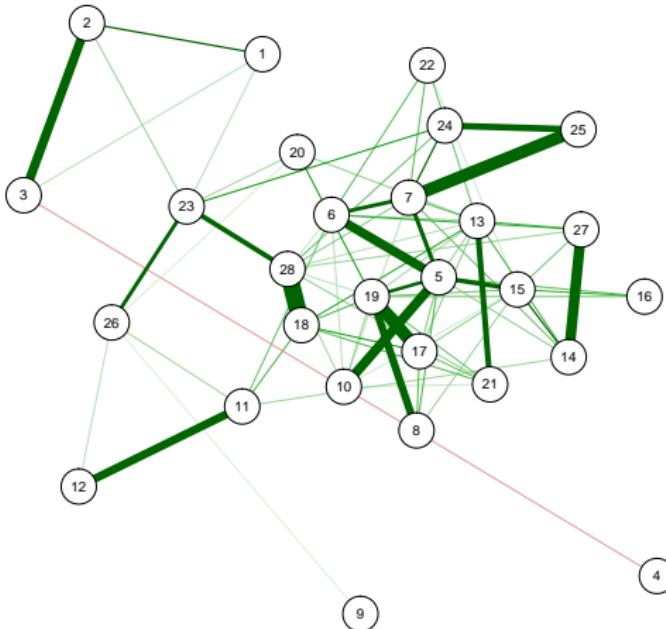
sample

$$\begin{matrix} 1 & X_A & 0.35 & 0.48 & 0.48 \\ 2 & X_B & -1.26 & -2.34 & -0.81 \\ 3 & X_C & -1.65 & 0.29 & -2.25 \\ \vdots & & \vdots & \vdots & \vdots \\ N & & -0.88 & -1.17 & 0.84 \end{matrix}$$

compute

Data

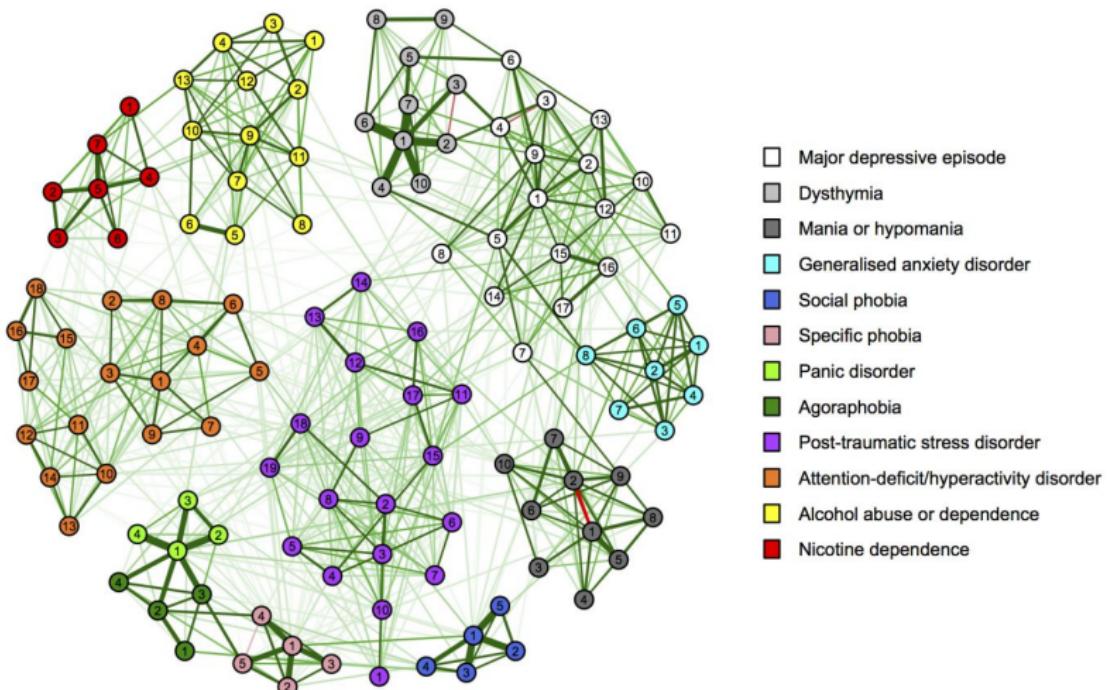
Conditional Independence Networks



- 1: Falling Asleep
 - 2: Sleep During the Night
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 - 25: Panic/Phobic symptoms
 - 26: Constipation/diarrhea
 - 27: Interpersonal Sensitivity
 - 28: Leader Paralysis/Physical Energy

Responses of 2460 individuals to Beck's Depression Inventory

Empirical Network vs. Classification Network



(Boschloo et al., 2015)

But wait ... what about causal direction?

So far we only talked about networks with undirected edges!

Two approaches:

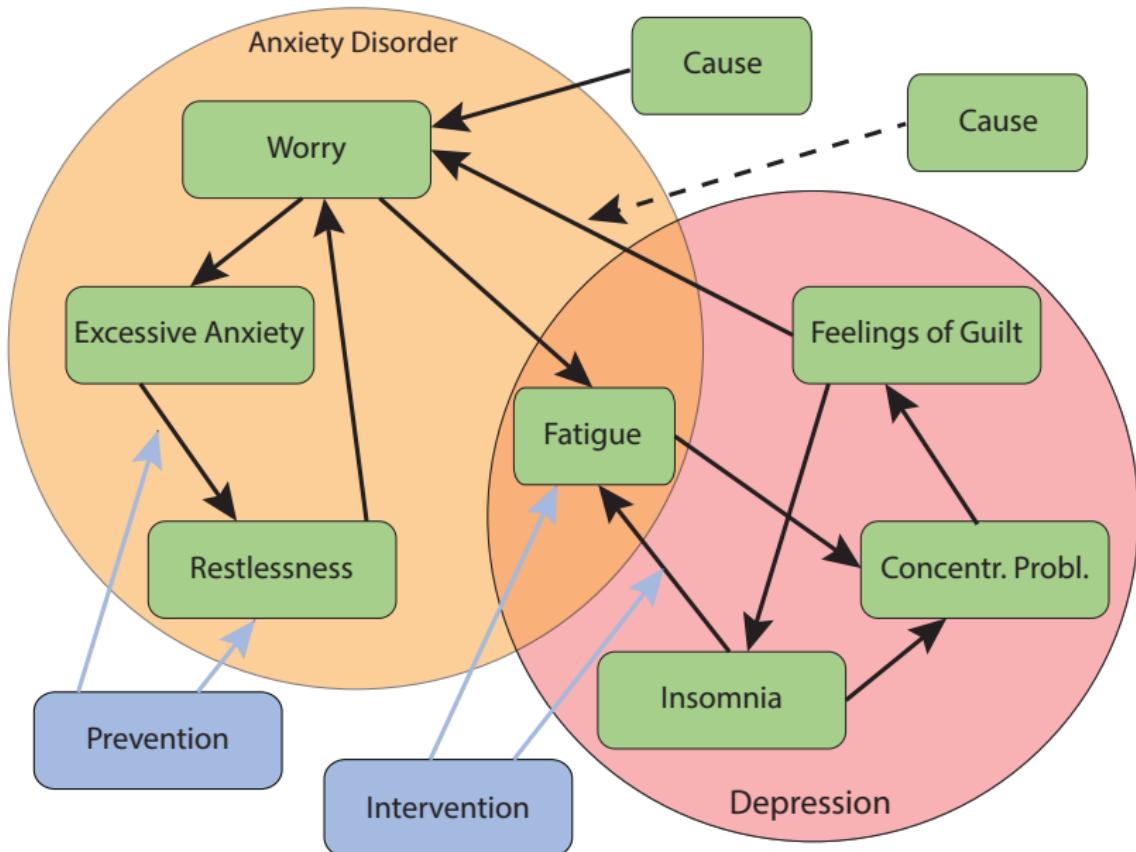
1. Pearl's do-calculus

- ▶ State of the art theory for cross-sectional data
- ▶ Based on counter-factuals
- ▶ Does not allow for cycles

2. Using the direction of time

- ▶ If A causes B, A must precede B
- ▶ We need within-person measurements!

Summary: Psychopathology as Causal Networks

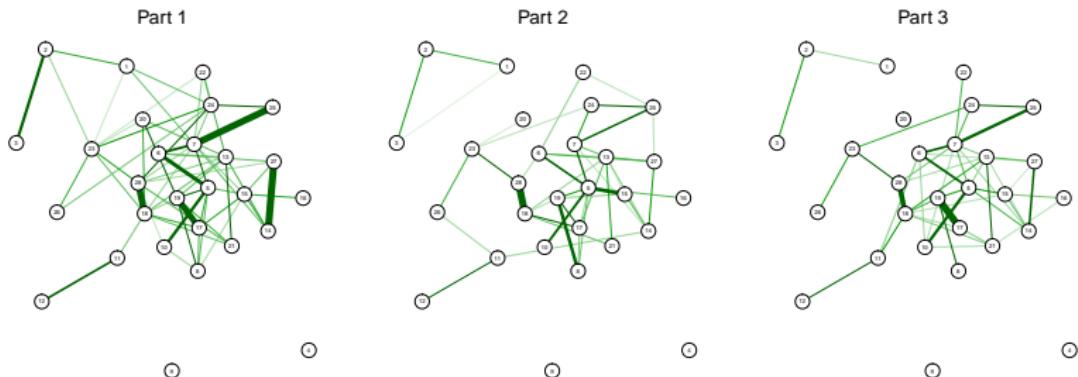


Problems with Cross-Sectional Data

- 1) How to infer causal direction?
- 2) We assume that all people are equal. Is this reasonable?

Are all people equal?

Simple test: randomly split the above dataset in 3 parts!

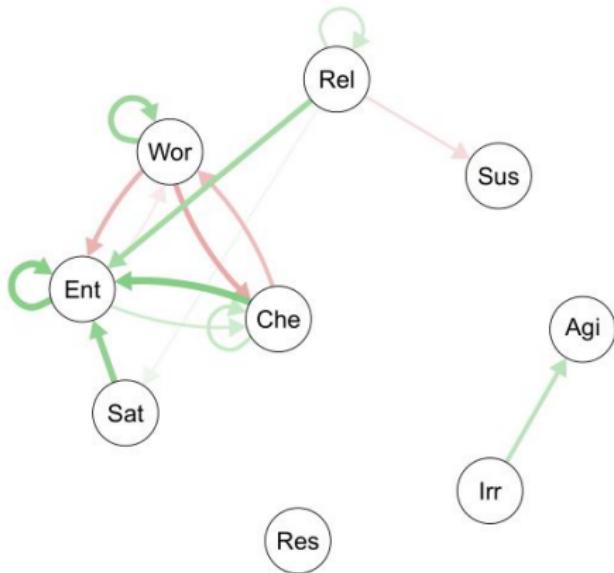


Networks are similar, but different!

Solution: Time Series Data

C	patientid	datum	mood_relax	mood_down	mood_irrit	mood_sad	mood_res	mood_long	beepno	beptime	resptime	resptime_end
1	20001	2011-06-24	6	1	1	5	5	1	10	2200	22:00:08	22:04:44
2	20001	2011-06-24	5	1	2	5	5	1	7	1646	16:48:12	16:49:55
4	20001	2011-06-24	5	1	2	5	5	1	8	1904	19:04:10	19:05:54
5	20001	2011-06-25	3	1	3	5	5	1	3	1128	11:28:27	11:30:25
6	20001	2011-06-25	4	2	2	3	5	1	10	2218	22:18:09	22:20:05
7	20001	2011-06-25	5	1	2	5	5	1	2	912	09:12:24	09:14:49
8	20001	2011-06-25	4	1	2	4	5	1	6	1514	15:14:24	15:16:17
9	20001	2011-06-25	5	1	1	5	5	1	1	746	07:46:26	07:48:50
10	20001	2011-06-25	5	1	1	5	5	1	7	1657	16:58:24	17:06:26
11	20001	2011-06-25	5	1	1	5	5	1	9	2008	20:09:19	20:11:02
12	20001	2011-06-25	6	1	1	6	5	1	8	1838	18:38:46	18:40:32
13	20001	2011-06-25	4	2	2	4	4	1	4	1242	12:42:13	12:43:56
14	20001	2011-06-25	5	1	2	5	5	1	5	1331	13:32:03	13:33:36
15	20001	2011-06-26	5	1	1	5	5	1	5	1338	13:38:23	13:40:05
16	20001	2011-06-26	5	1	1	5	5	1	6	1536	15:36:34	15:37:41
17	20001	2011-06-26	5	1	1	5	5	1	3	1117	11:18:33	11:20:34
18	20001	2011-06-26	5	1	1	5	5	1	7	1730	17:30:50	17:32:16
19	20001	2011-06-26	5	1	1	5	5	1	9	2054	20:54:12	20:55:29
20	20001	2011-06-26	5	1	1	4	5	1	1	746	07:46:40	07:50:25
21	20001	2011-06-26	5	1	1	5	5	1	4	1206	12:06:22	12:07:52
22	20001	2011-06-26	5	1	1	5	5	1	2	918	09:18:10	09:19:53
23	20001	2011-06-26	5	1	1	5	5	1	10	2130	21:30:15	21:31:32
24	20001	2011-06-27	4	2	1	4	5	1	3	1034	10:34:29	10:36:08

One Possible Model: Vector Autoregression



Rel: Relaxed
Irr: Irritated
Sat: Satisfied
Ent: Enthusiastic
Sus: Suspicious
Che: Cheerful
Res: Restless
Agi: Agitated
Wor: Worry

Check out the Network Analysis Workshop!



When? Wed, 14.30-16.00

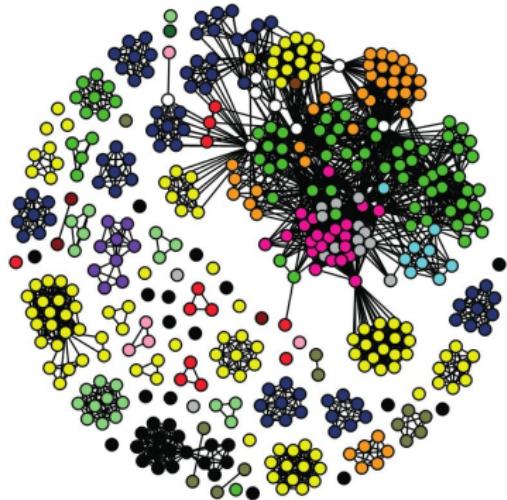
Where? Indico (2nd floor)

Topics:

- ▶ What are networks?
- ▶ Generate networks
- ▶ Correlation networks
- ▶ Estimating independence networks
- ▶ Network Visualization

Please install R and RStudio beforehand!

More Info & Contact



More Info:
Psychosystems.org

Contact:
jonashaslbeck@gmail.com
jmbh.github.io

References

- ▶ Borsboom, D., Cramer, A. O., Schmittmann, V. D., Epskamp, S., & Waldorp, L. J. (2011). The small world of psychopathology. *PLoS one*, 6(11), e27407.
- ▶ Borsboom, D., & Cramer, A. O. (2013). Network analysis: an integrative approach to the structure of psychopathology. *Annual review of clinical psychology*, 9, 91-121.
- ▶ Tio, P., Epskamp, S., Noordhof, A., & Borsboom, D. (2016). Mapping the manuals of madness: Comparing the ICD10 and DSMIVTR using a network approach. *International Journal of Methods in Psychiatric Research*.
- ▶ Schmaal, L., Veltman, D. J., van Erp, T. G., Smann, P. G., Frodl, T., Jahanshad, N., ... & Vernooij, M. W. (2015). Subcortical brain alterations in major depressive disorder: findings from the ENIGMA Major Depressive Disorder working group. *Molecular Psychiatry*.
- ▶ Boschloo, L., van Borkulo, C. D., Rhemtulla, M., Keyes, K. M., Borsboom, D., & Schoevers, R. A. (2015). The Network Structure of Symptoms of the Diagnostic and Statistical Manual of Mental Disorders. *PLoS one*, 10(9), e0137621.