

NETWORK PSYCHOMETRICS

uma introdução

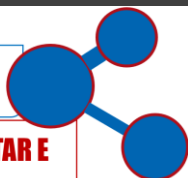
Prof. Dr. Wagner de Lara
Machado

PPG Psicologia

Escola de Ciências da Saúde
PUCRS

GRUPO DE PESQUISA

AVALIAÇÃO EM BEM-ESTAR E
SAÚDE MENTAL



MELHOR
PÓS-GRADUAÇÃO
DO BRASIL

AVALIAÇÃO QUADRIENAL DA CAPES

PSICOLOGIA
Nota 6

Excelência Internacional

Quem sou eu?

- Psicólogo (ULBRA)
- Mestre e Doutor em Psicologia (UFRGS)
- Estágio de Pós-doutorado (UFRGS)
- Professor do PPG Psicologia da PUCRS (Nota 6 CAPES)
- Grupo de pesquisa:

Avaliação em Bem-estar e Saúde Mental







Network Analysis?

Análise de rede aplicada à psicometria e a avaliação psicológica



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Assistant Professor in Psychological Methods and Psychometrics at the University of Amsterdam

Wagner de Lara Machado

Pontifícia Universidade Católica de Campinas

João Ricardo Nickenig Vissoci

Faculdade Ingá e Duke University

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Universiteit van Amsterdam



João Vissoci

Pesquisador na divisão de Emergency Medicine do departamento de Cirurgia, e na divisão Duke Global Neurosurgery and Neuroscience (DGNN) do departamento de Neurocirurgia, na Duke University

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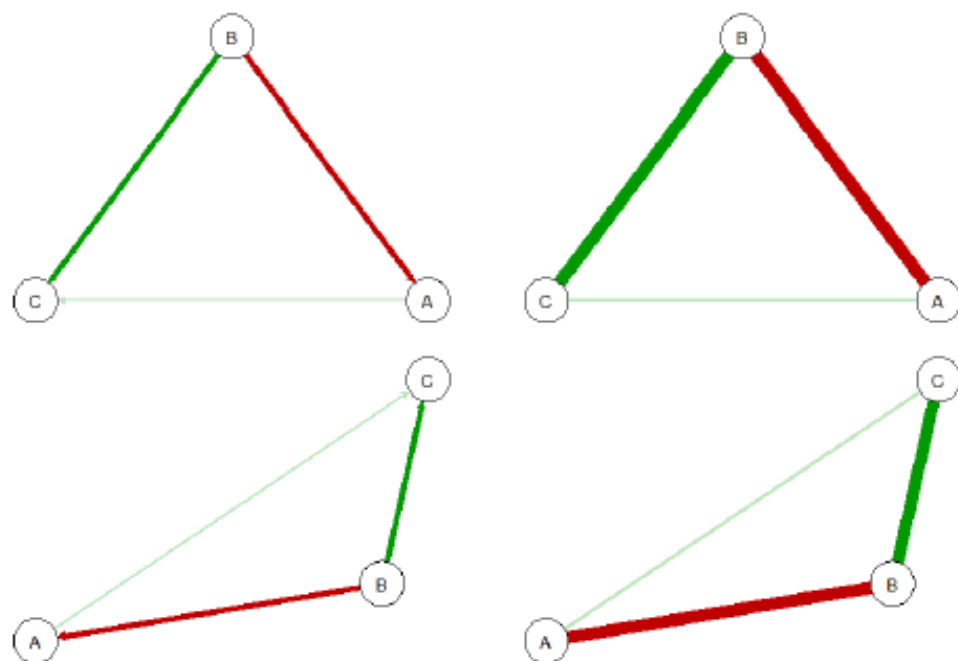


Figura 5. Redes ponderadas, direcionais e não-direcionais, sem (acima) e com (abaixo) o emprego do algoritmo de posicionamento.

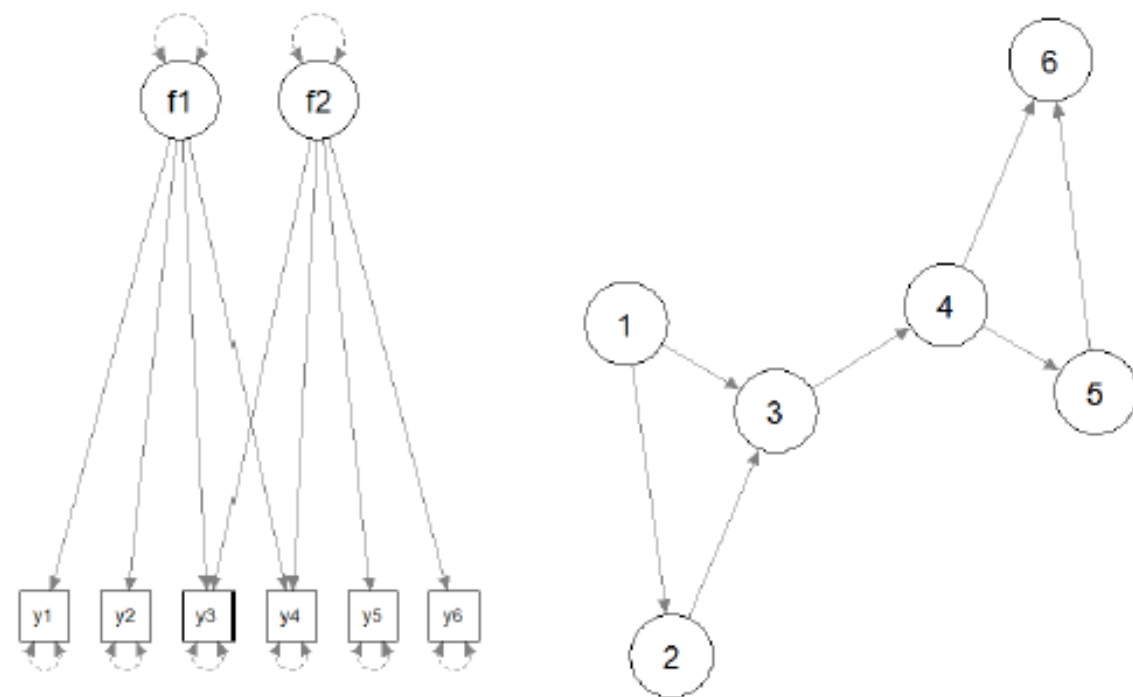


Figura 13. Modelo de traço latente (esquerda) e de rede (direita) da comorbidade.

Positive Mental Health Scale: Validation of the *Mental Health Continuum – Short Form*

Wagner de Lara Machado – Pontifícia Universidade Católica de Campinas, Campinas, São Paulo, Brasil

Denise Ruschel Bandeira – Universidade Federal do Rio Grande do Sul, Porto Alegre, Brasil

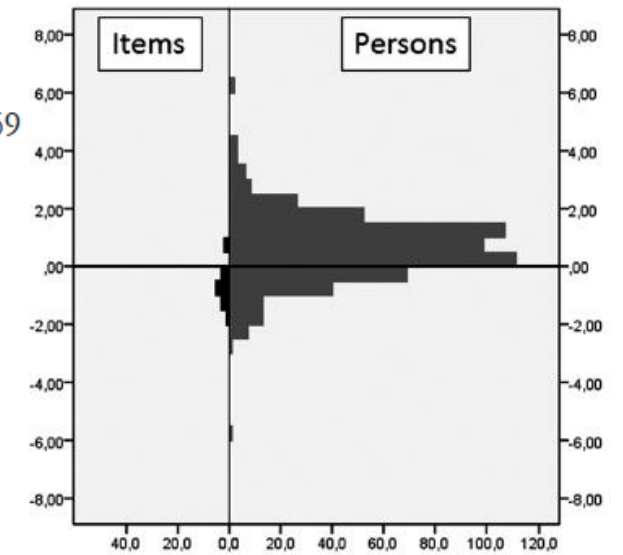


Figure 1. Map of items and persons. The vertical axis indicates the scale in logits. The distribution was obtained by fixing the contrary measure so the mean would be equal to zero.

Table 2

Item Factor Loadings and Reliability Measures of the MHC-SF in the Bifactor Model

Item (summarized content)	Factor loading			
	General factor	EWB	SWB	PWB
1 – Happy	.70	.65		
2 – Interested	.78	.32		
3 – Satisfied	.78	.36		
4 – Contribute to society	.69		.07	
5 – Belong to community	.67		.23	
6 – Society is becoming a better place	.62		.63	
7 – People are good	.62		.41	
8 – Way society works makes sense	.57		.56	
9 – Likes own personality	.79			.21
10 – Manages responsibility well	.70			.19
11 – Relationships with others	.72			.24
12 – Grow and become a better person	.62			.39
13 – Confident to express own ideas	.68			.52
14 – Life has direction or meaning	.83			.12
Average extracted variance	.49	.22	.19	.10
Composite reliability	.93	.43	.47	.34

Note. EWB = emotional well-being, SWB = social well-being, PWB = psychological well-being.

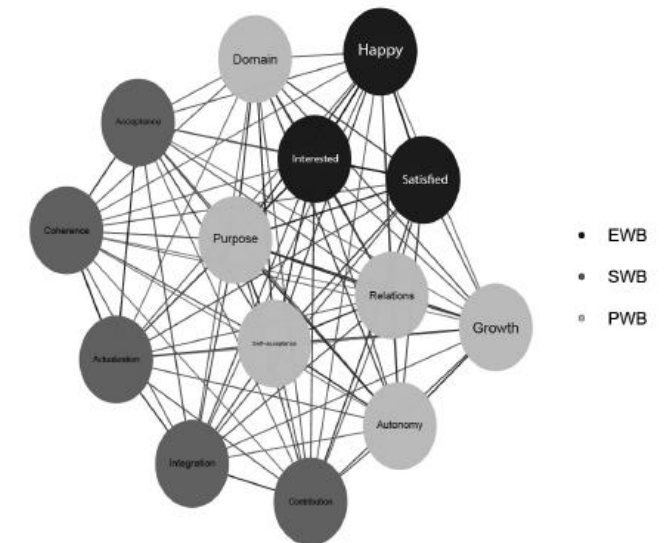


Figure 2. Network of positive mental health indicators. The covariance structure indicates that the MHC-SF items are strongly associated with the others, resulting in a dense component. The items in the emotional (EWB), social (SWB) and psychological (PWB) well-being subscales exhibit moderate to strong crossed associations. Purpose in life and self-acceptance are the central nodes of the system, meaning that they are more strongly associated with the remainder of the items. The stronger line represents the correlation between “happy” and “satisfied” ($r_{1,3} = .78$); the fainter line represents the correlation between “relations” and “coherence” ($r_{8,11} = .35$).



The Experience of Sexual Stigma and the Increased Risk of Attempted Suicide in Young Brazilian People from Low Socioeconomic Group

Angelo Brandelli Costa^{1*}, Andrew Pasley², Wagner de Lara Machado³, Ernesto Alvarado⁴, Luciana Dutra-Thomé⁴ and Silvia Helena Koller⁴

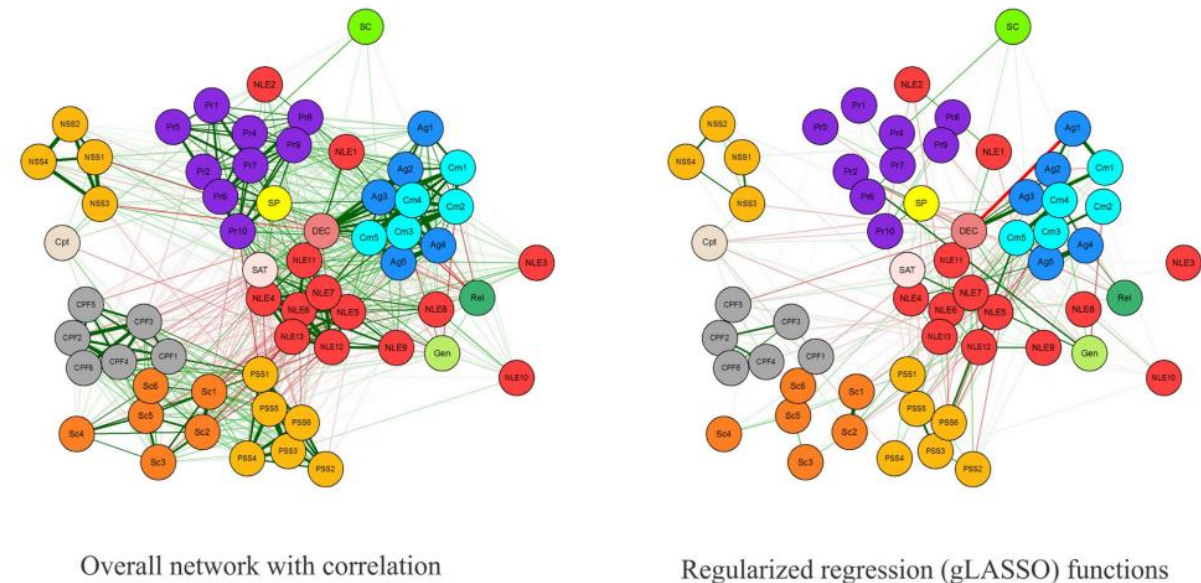


FIGURE 1 | Overall network with correlation (left) and regularized regression (gLASSO) functions (right). Variables names match those in Table 1.

This study was intended to analyze the intersection of experience of sexual stigma low-socioeconomic status, and suicide attempt amongst young Brazilians (11–24 years old). In each of the data collection periods (2004–2006: $n = 7185$; 2010–2012: $n = 2734$), participants completed a questionnaire-based instrument. Network analysis provided support for a Minority Stress Model, oriented around whether participants had experienced sexual stigma. Although suicide attempts decreased by 20% for participants

Iniciando...

- Acesse: <https://github.com/wagnerLM/>
- Selecione o curso_redes: <https://github.com/wagnerLM/netusf>
- Abra seu RStudio
- Acesse o script em:
<https://github.com/wagnerLM/netusf/blob/master/R%20script%20USF%202019.R>
- Acesse a apresentação em:
<https://github.com/wagnerLM/netusf/blob/master/netUSF%20atual.pdf>

RStudio

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professional software for R

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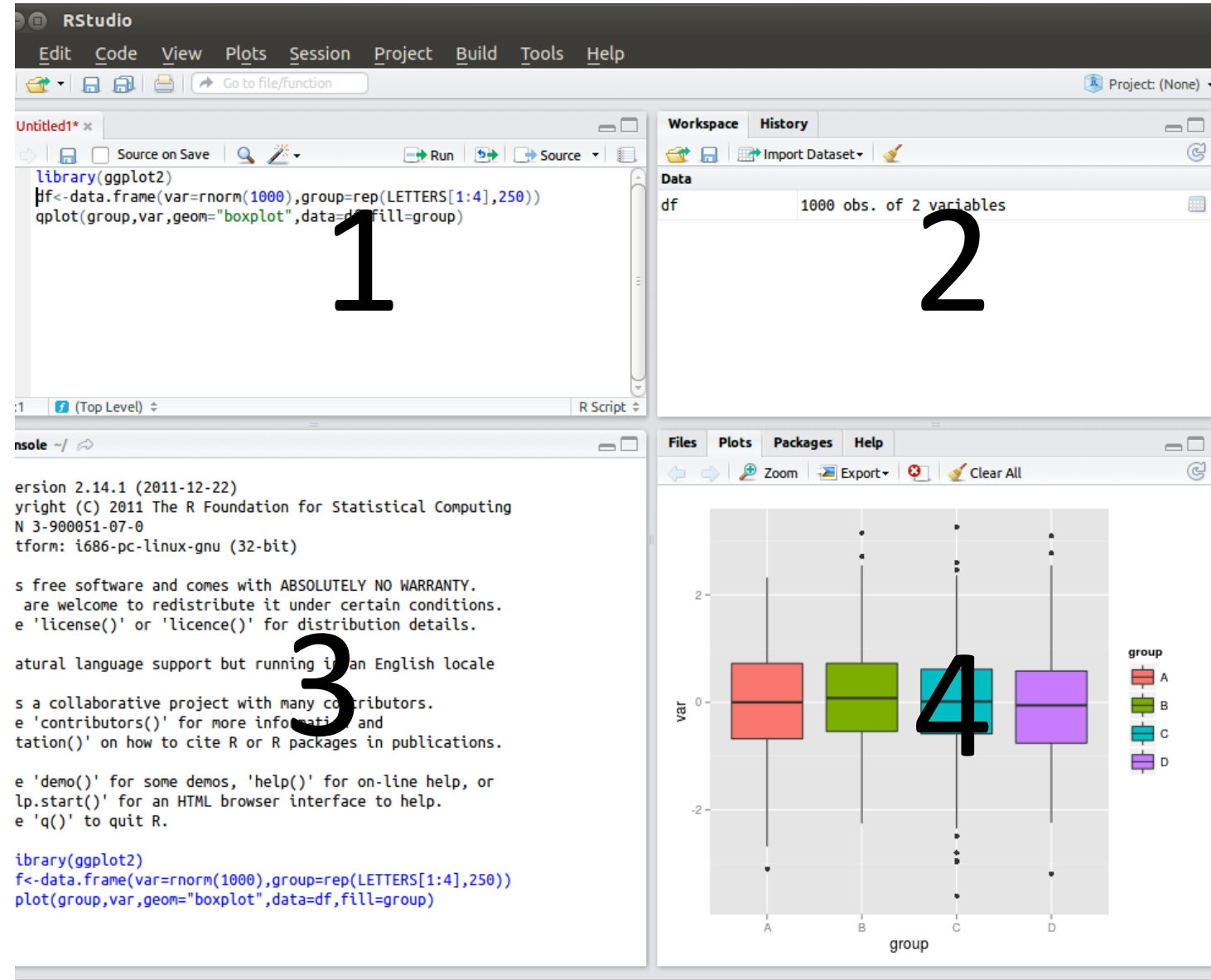
RStudio

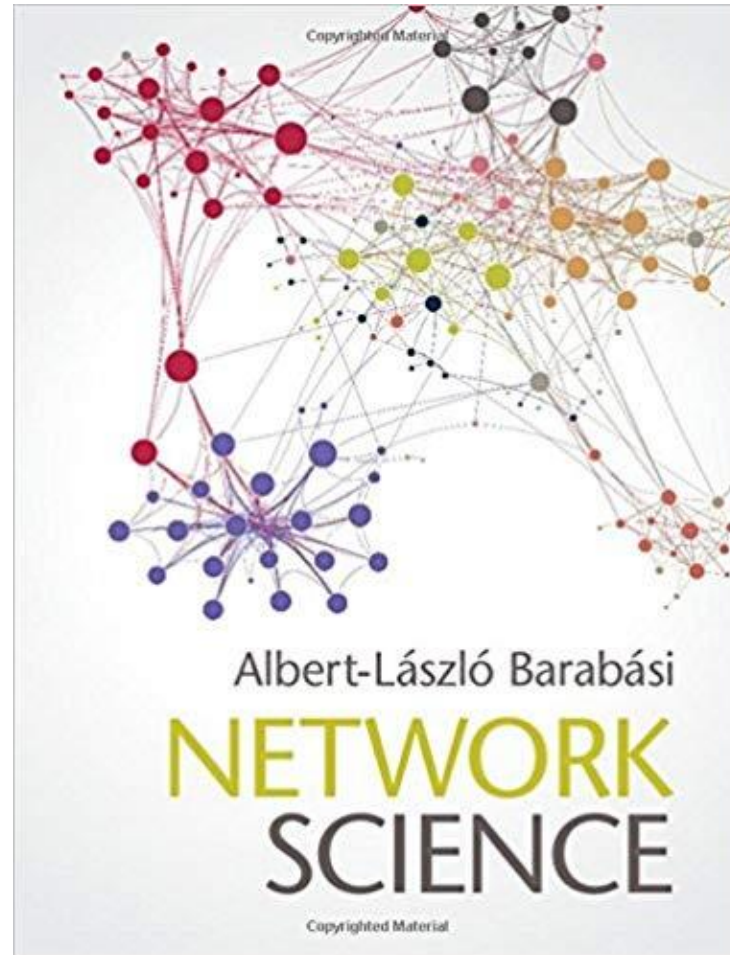
1 – script ou comandos; visualização de bancos de dados ou texto

2 – repositório de objetos e funções

3 – log de atividade

4 – gráficos e documentação





“Reductionism, as a paradigm, is expired, and complexity, as a field, is tired. Data-based mathematical models of complex systems are offering a fresh perspective, rapidly developing into a new discipline: network science.”

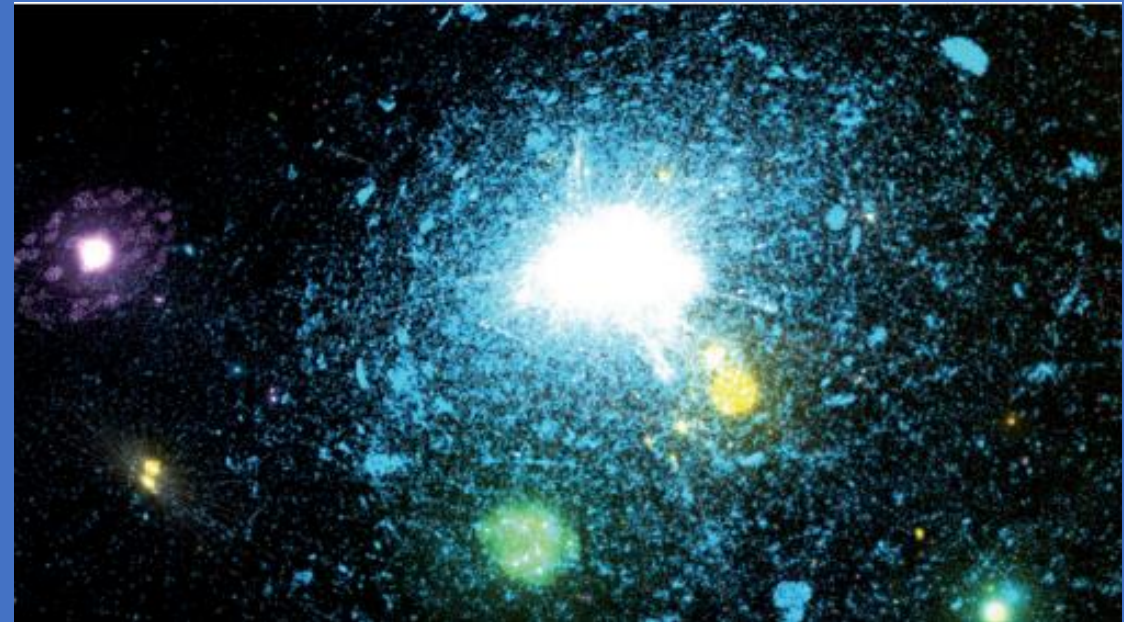
NATURE PHYSICS | COMMENTARY

The network takeover

Albert-László Barabási

Nature Physics **8**, 14–16 (2012) | doi:10.1038/nphys2188

Published online 22 December 2011



Modelos de rede na psicologia

- Algumas publicações importantes no estudo da psicopatologia (clínica) e personalidade

Psychometric Perspectives on Diagnostic Systems



1102

Journal of Clinical Psychology, September 2008

Denny Borsboom

University of Amsterdam

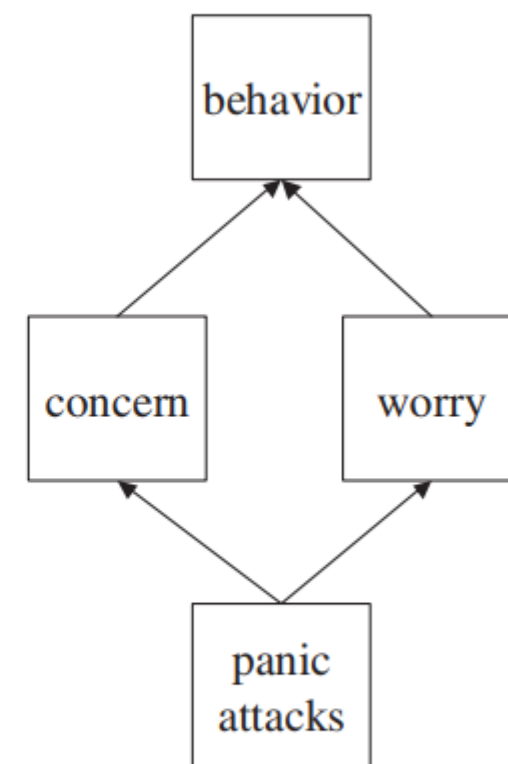
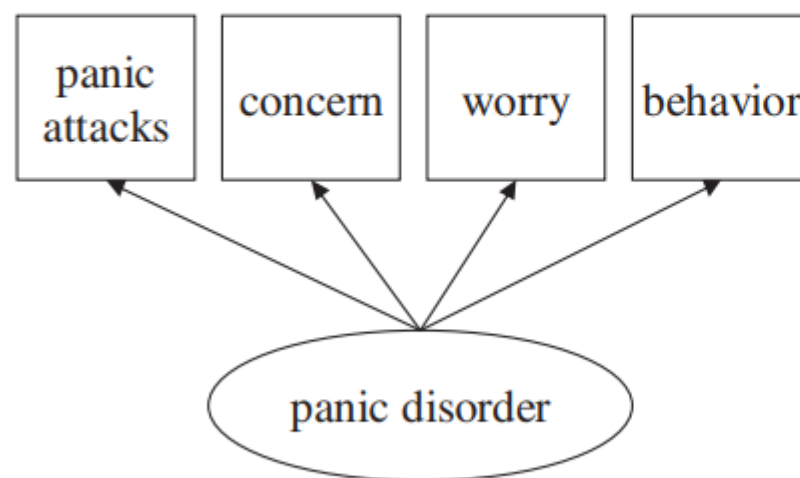


Figure 1. The left panel shows the relation between panic disorder and its symptoms from a latent variable modeling point of view. The right panel shows a representation of these symptoms as a causal system.

Comorbidity: A network perspective

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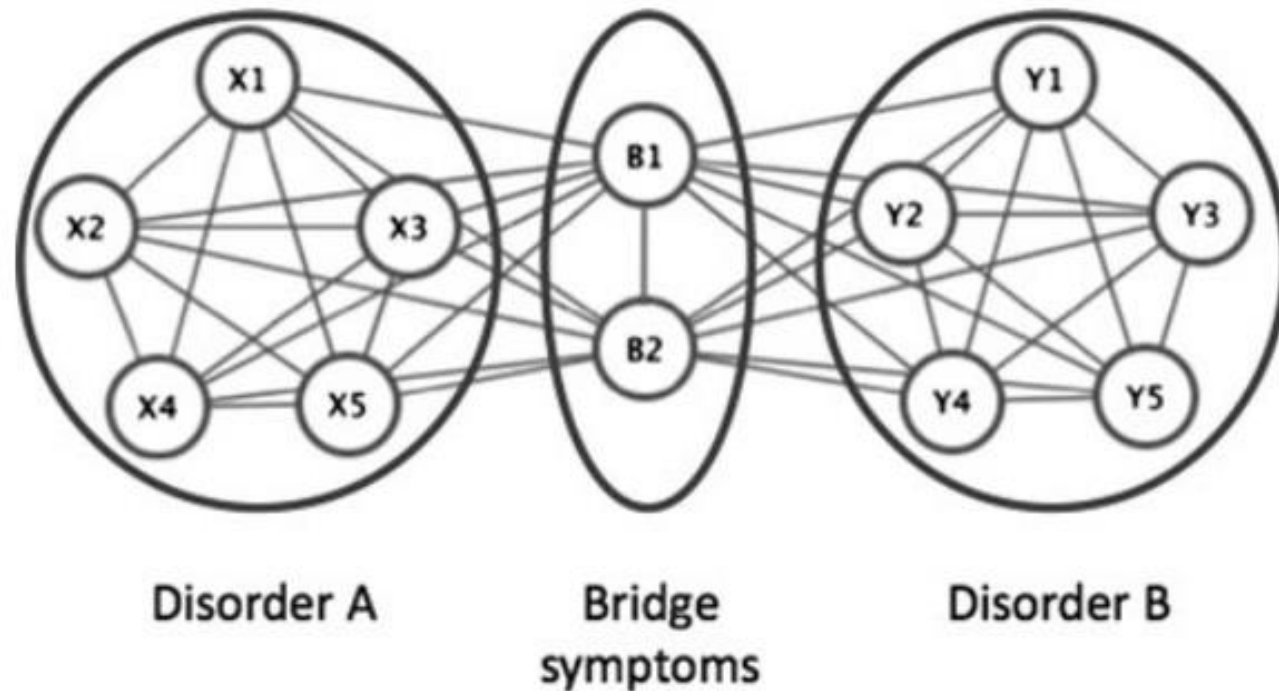


Figure 2. Comorbidity under a network approach. Disorder A consists of bidirectionally related symptoms $X_1 - X_5$, and disorder B consists of symptoms $Y_1 - Y_5$. Symptoms B_1 and B_2 are *bridge symptoms* that overlap between disorders A and B. In this model, comorbidity arises as a result of direct relations between the bridge symptoms of two disorders.

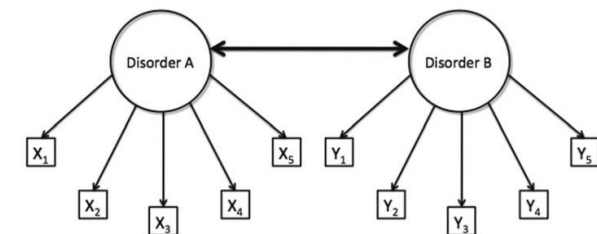


Figure 1. A model of comorbidity between disorders A and B, under the standard assumptions of latent variable modeling. The *circles* represent the disorders (i.e., latent variables) and the *rectangles* represent the observable core symptoms of those disorders (i.e., $X_1 - X_5$ for disorder A, and $Y_1 - Y_5$ for disorder B). In this model, comorbidity is viewed as a correlation between the latent variables, visualized by the *thick bidirectional edge* between disorders A and B.

The Small World of Psychopathology

Denny Borsboom*, Angélique O. J. Cramer, Verena D. Schmittmann, Sacha Epskamp, Lourens J. Waldorp

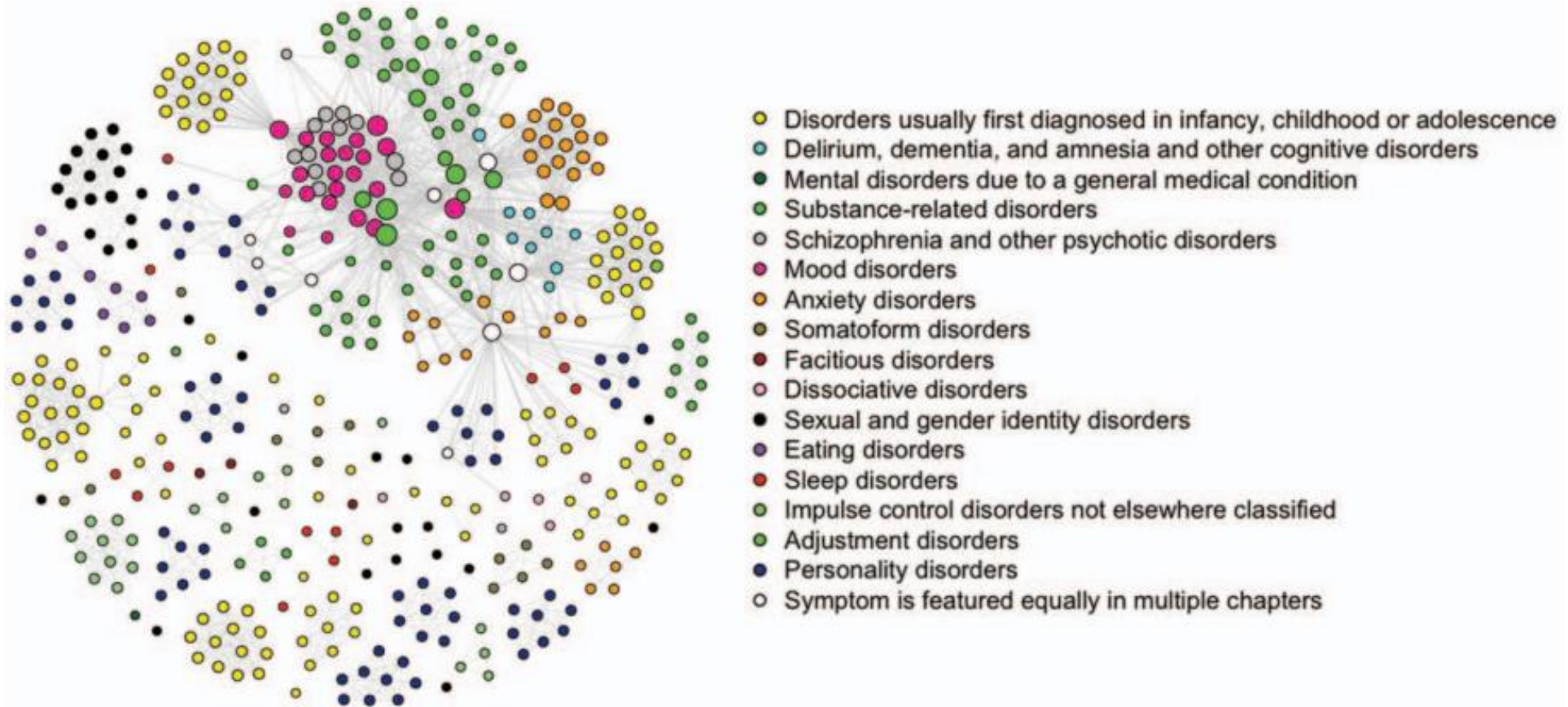


Figure 2. The DSM-IV symptom space. Symptoms are represented as nodes and connected by an edge whenever they figure in the same disorder. Color of nodes represents the DSM-IV chapter in which they occur most often.

doi:10.1371/journal.pone.0027407.g002



Journal of Statistical Software

May 2012, Volume 48, Issue 4.

<http://www.jstatsoft.org/>

qgraph: Network Visualizations of Relationships in Psychometric Data

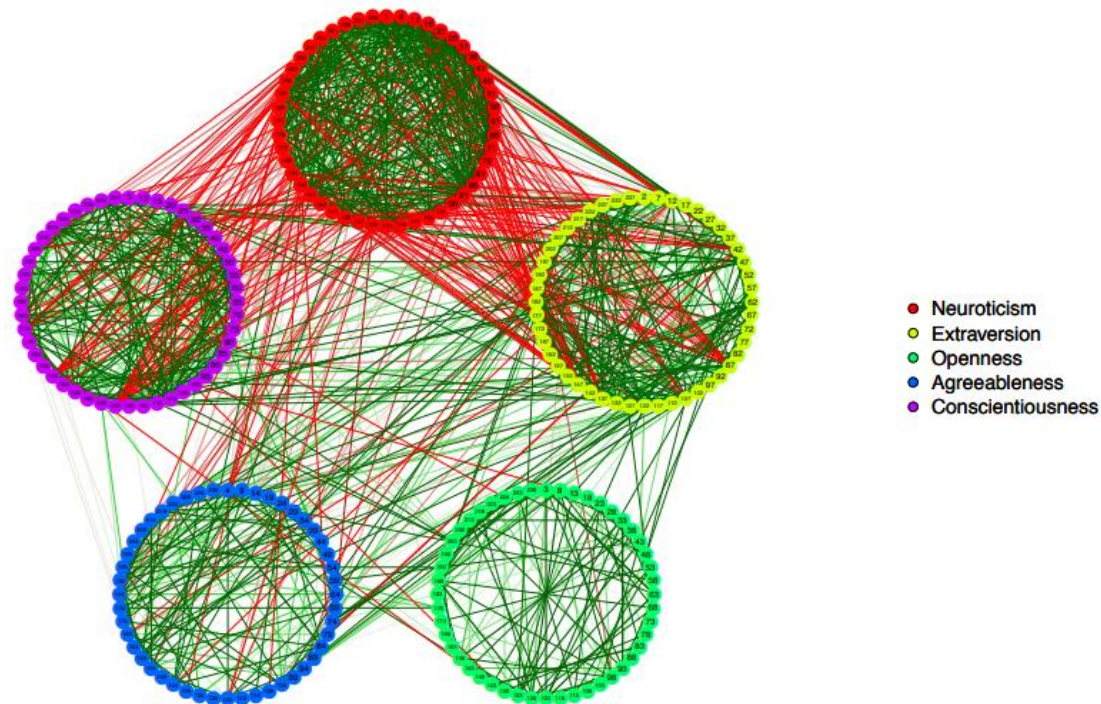
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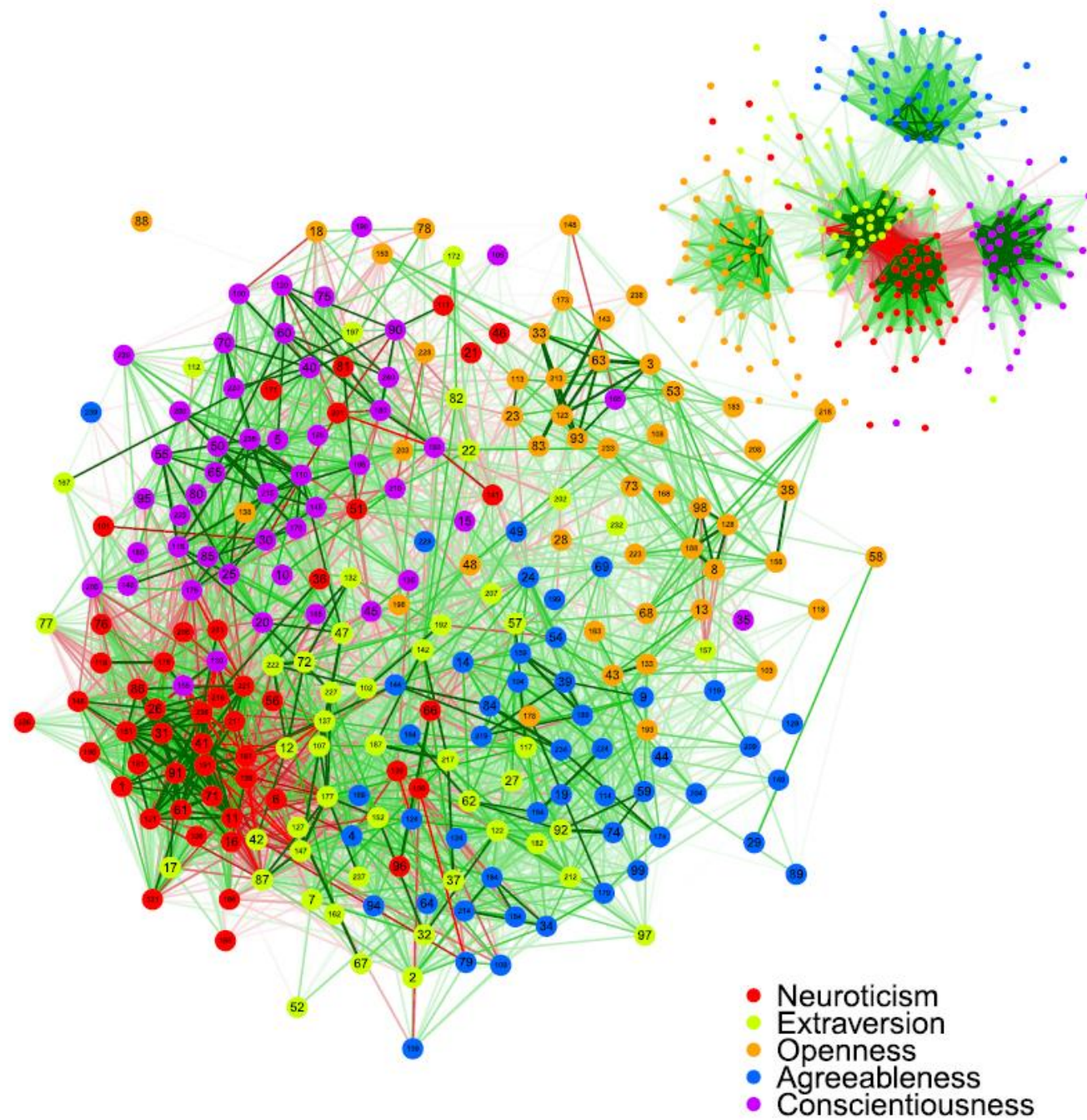
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University of Amsterdam

Lourens J. Waldorp
University of Amsterdam

Verena D. Schmittmann
University of Amsterdam

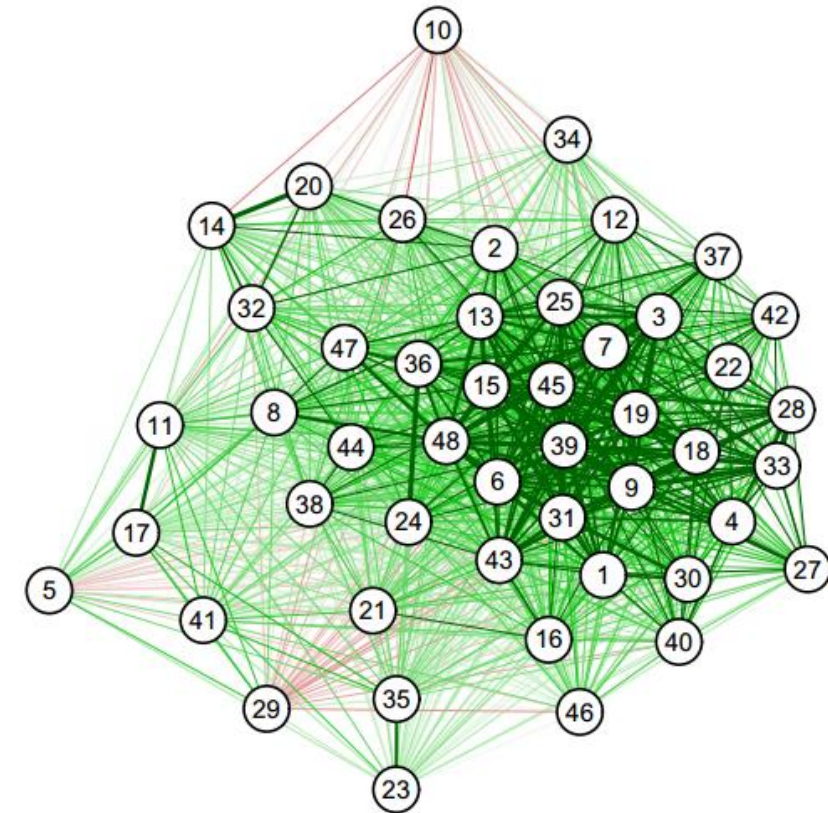
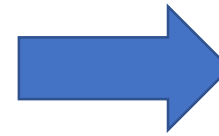
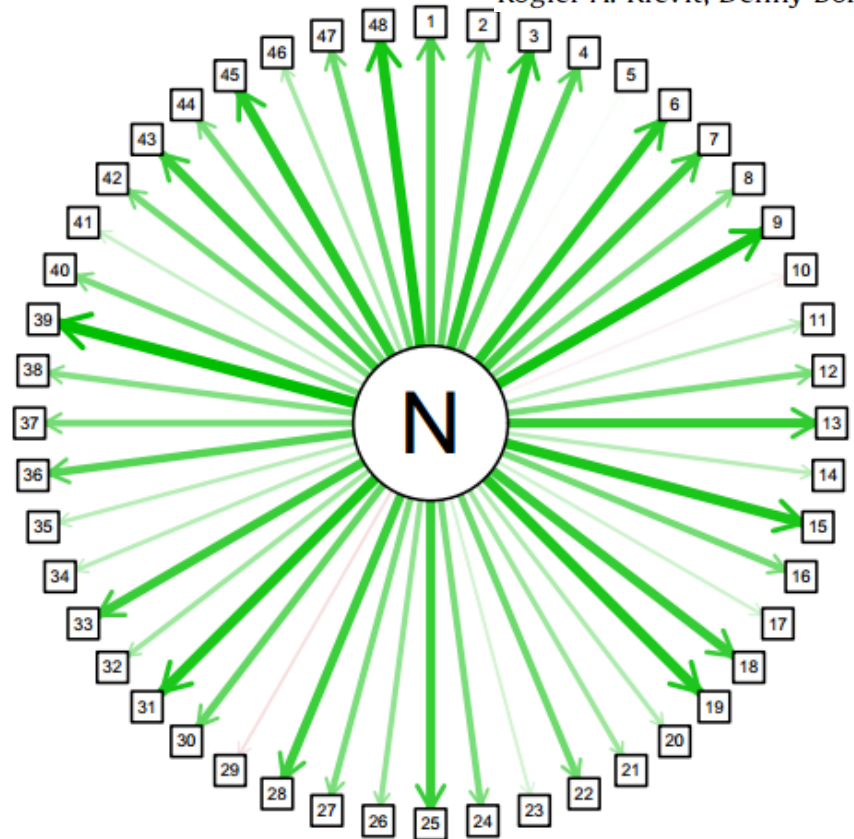
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Deconstructing the construct: A network perspective on psychological phenomena

Verena D. Schmittmann, Angélique O.J. Cramer, Lourens J. Waldorp, Sacha Epskamp, Rogier A. Kievit, Denny Borsboom*



Deconstructing the construct: A network perspective on psychological phenomena

Verena D. Schmittmann, Angélique O.J. Cramer, Lourens J. Waldorp, Sacha Epskamp, Rogier A. Kievit, Denny Borsboom*



Fig. 6. The best fitting confirmative time series model of the following five constituents of depression: tiredness; concentration difficulties (*concentration*); self-content; sad mood; pleasure in current activity (*activity*).

Análise de rede

- O que está em jogo é uma hipótese:

Para alguns fenômenos psicológicos os modelos de traços latentes não sejam os mais apropriados, mas sim aqueles que estimam a interação direta e recíproca entre seus componentes (e.g. redes)

- Analisar a informação útil em cada um dos modelos psicométricos

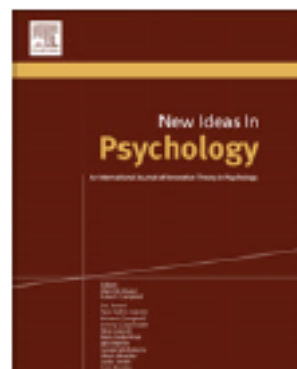


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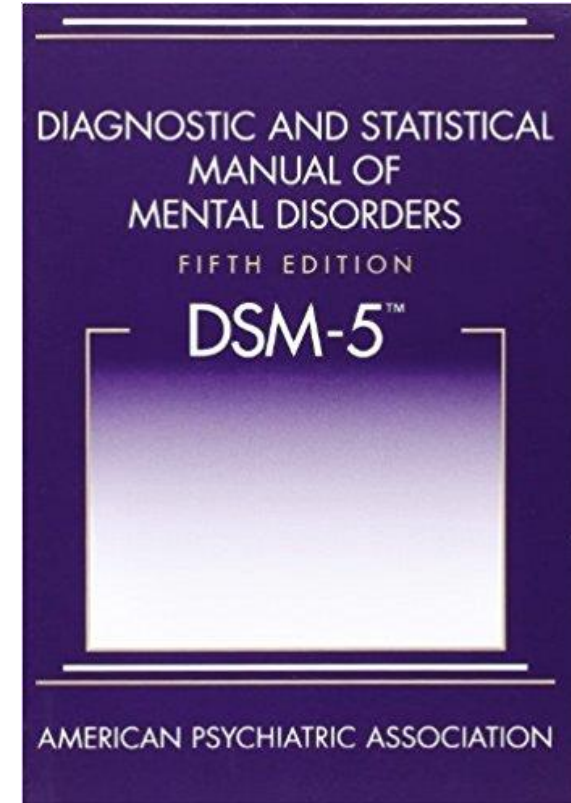
Deconstructing the construct: A network perspective on psychological phenomena

Verena D. Schmittmann, Angélique O.J. Cramer, Lourens J. Waldorp, Sacha Epskamp, Rogier A. Kievit, Denny Borsboom*

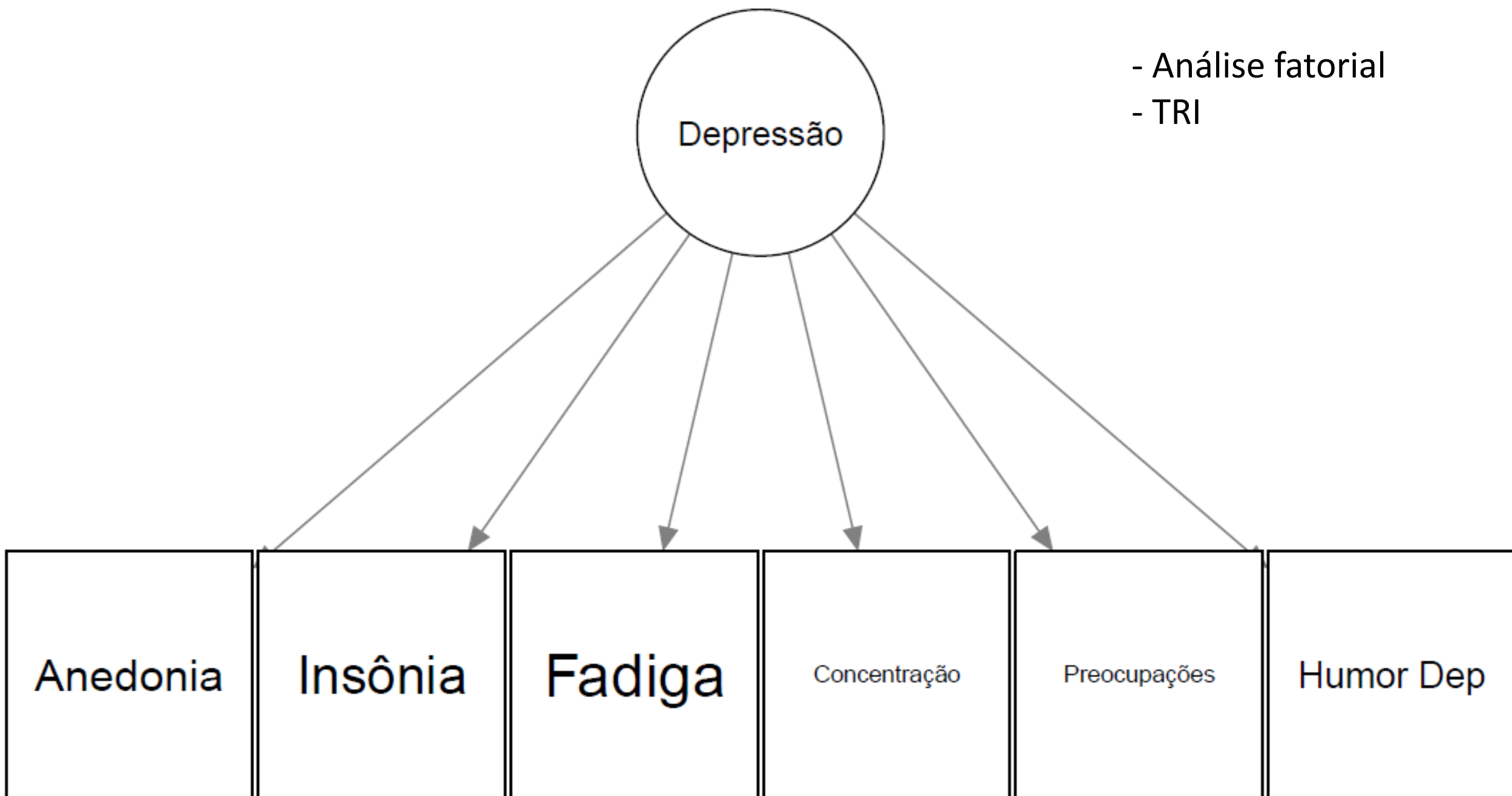
Avaliação em saúde mental: traços latentes e redes

- **Transtorno depressivo maior:**

- Humor deprimido
- Diminuição do interesse ou prazer
- Perda ou ganho significativo de peso
- Insônia ou hipersonia
- Agitação ou retardo psicomotor
- Fadiga ou perda de energia
- Sentimentos de inutilidade ou culpa
- Capacidade diminuída para pensar ou se concentrar
- Pensamentos recorrentes de morte



- Análise fatorial
- TRI



Measuring Depression Over Time . . . or not? Lack of Unidimensionality and Longitudinal Measurement Invariance in Four Common Rating Scales of Depression

Eiko I. Fried
University of Leuven

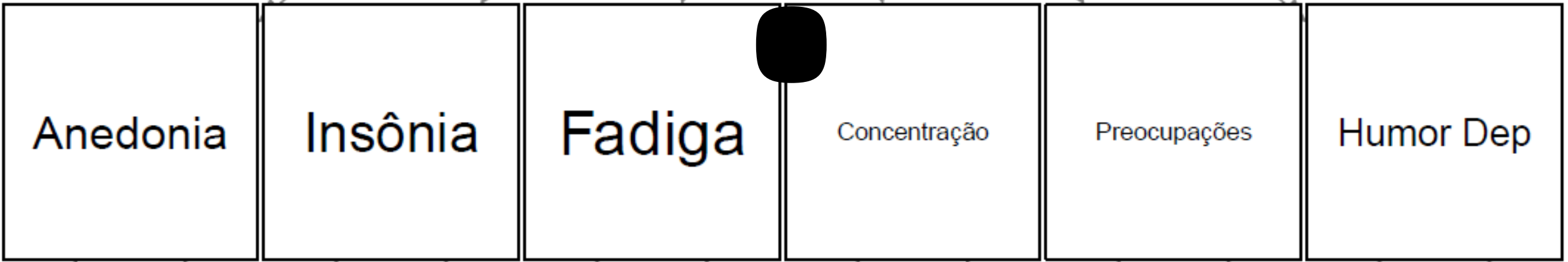
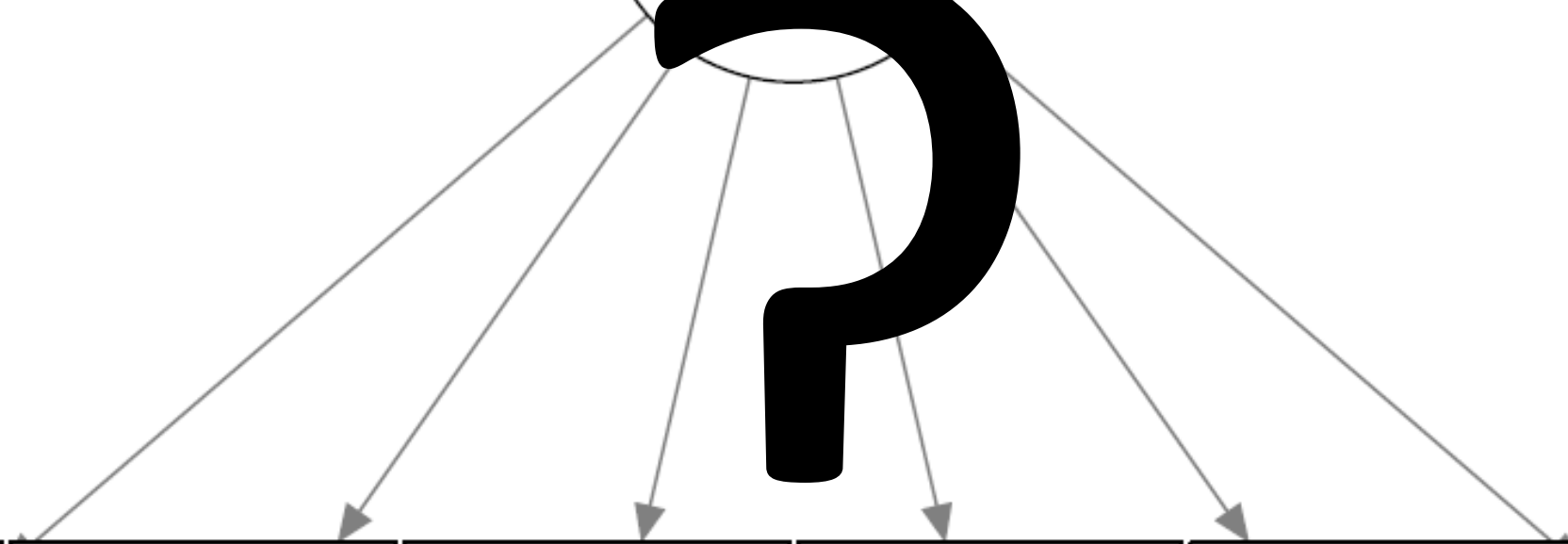
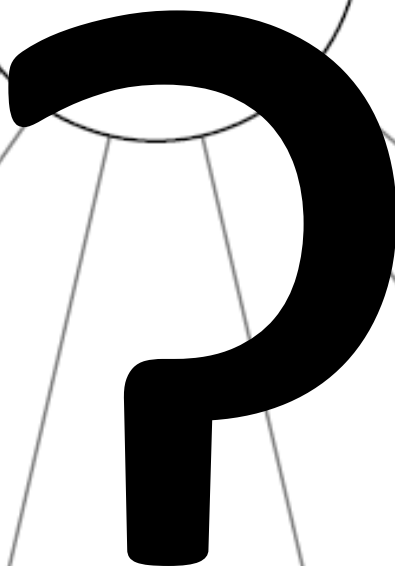
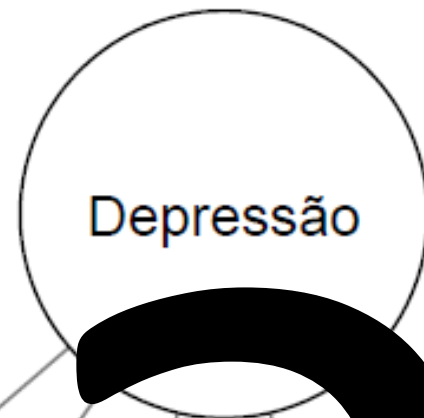
Claudia D. van Borkulo
University of Groningen and University of Amsterdam

Sacha Epskamp
University of Amsterdam

Robert A. Schoevers
University of Groningen

Francis Tuerlinckx
University of Leuven

Denny Borsboom
University of Amsterdam



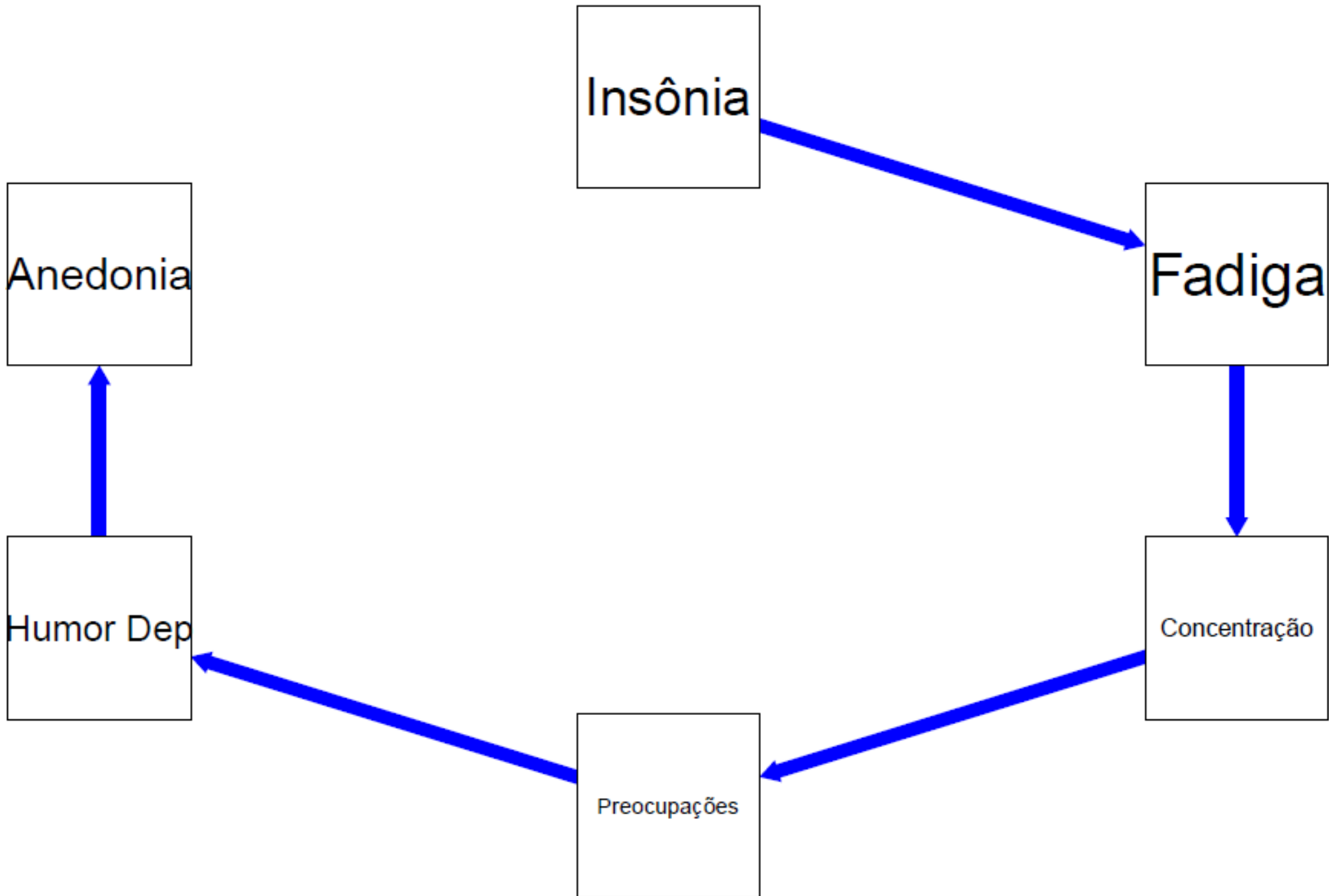
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Verena D. Schmittmann, Angélique O.J. Cramer, Lourens J. Waldorp, Sacha Epskamp, Rogier A. Kievit, Denny Borsboom*

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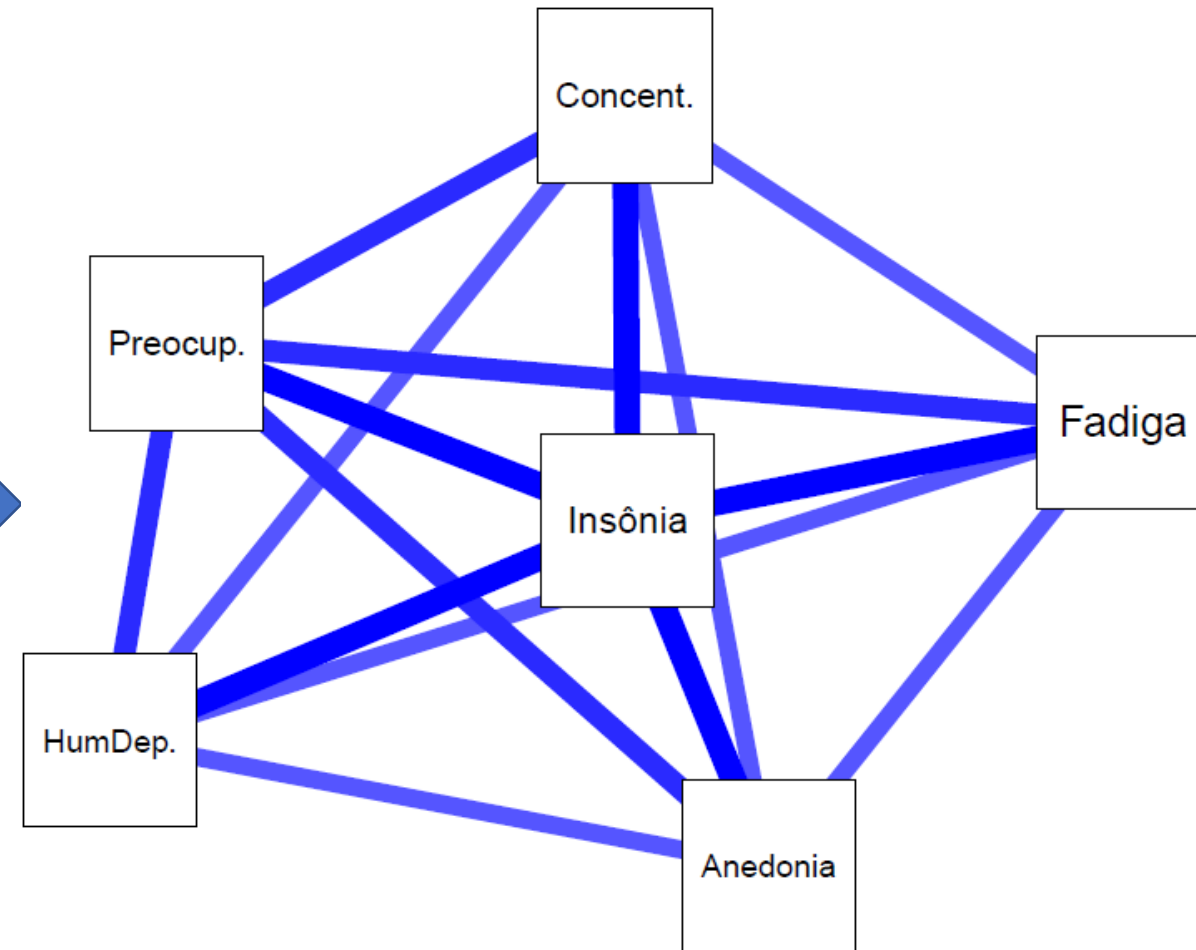


Fig. 6. The best fitting confirmative time series model of the following five constituents of depression: tiredness; concentration difficulties (*concentration*); self-content; sad mood; pleasure in current activity (*activity*).



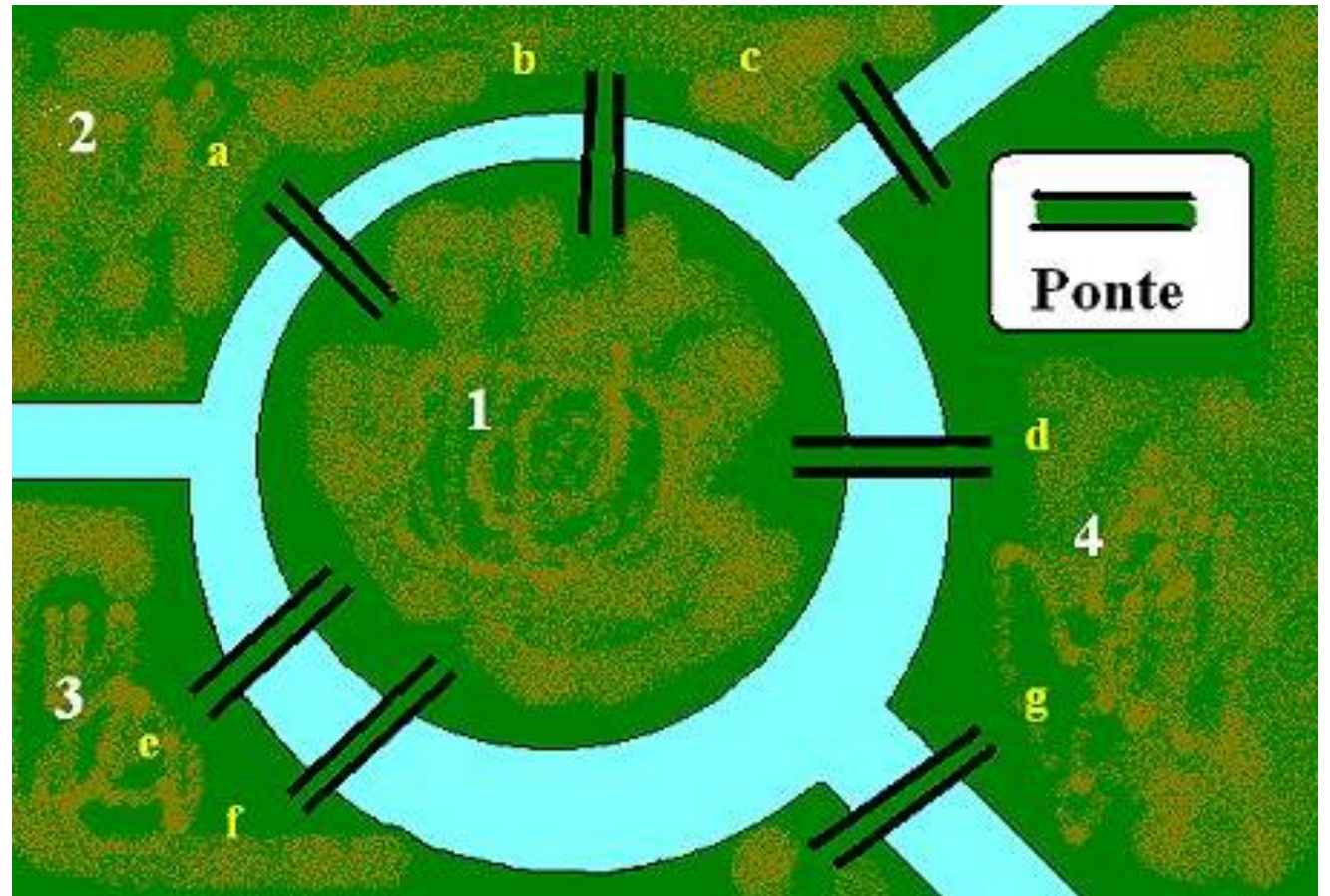
Depressão: estrutura e dinâmica de um sistema

▲	Insônia ▲	Fadiga ▲	Concent. ▲	Preocup. ▲	HumDep. ▲	Anedonia ▲
Insônia	1.0	0.6	0.6	0.6	0.6	0.6
Fadiga	0.6	1.0	0.4	0.5	0.4	0.4
Concent.	0.6	0.4	1.0	0.5	0.4	0.4
Preocup.	0.6	0.5	0.5	1.0	0.5	0.5
HumDep.	0.6	0.4	0.4	0.5	1.0	0.4
Anedonia	0.6	0.4	0.4	0.5	0.4	1.0



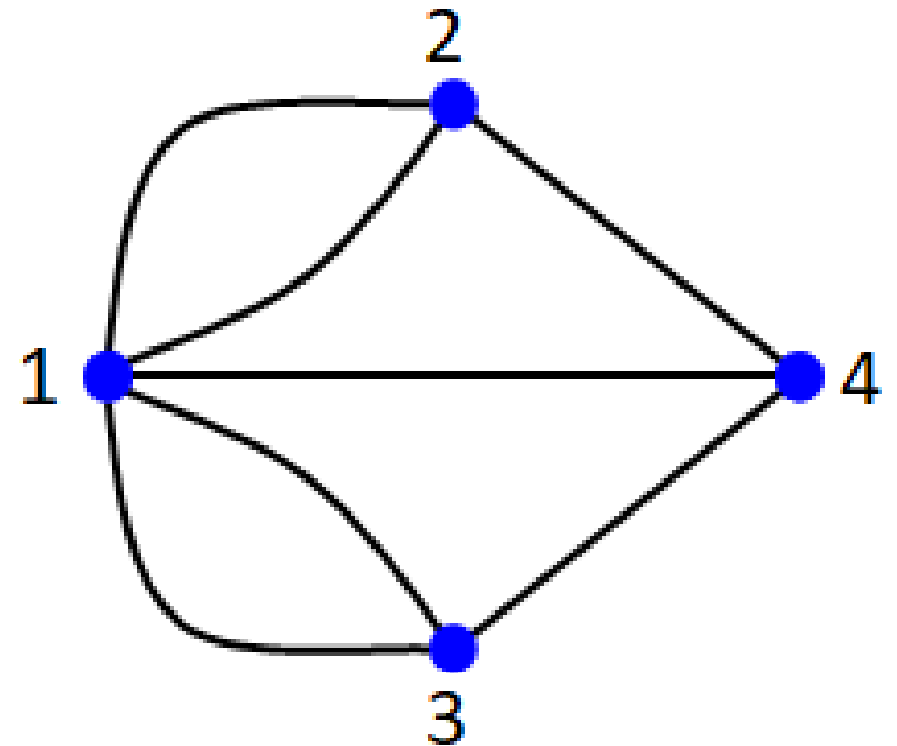
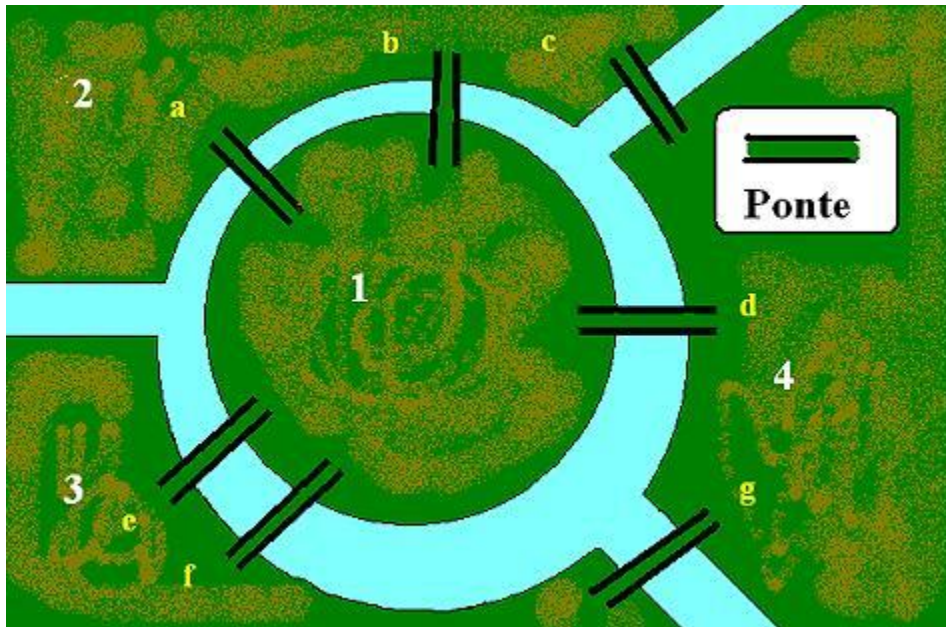
Teoria dos grafos

- O problema das pontes de Königsberg
- Discutia-se nas ruas da cidade a possibilidade de atravessar todas as pontes sem repetir nenhuma



Teoria dos grafos

- Havia uma lenda popular sobre a possibilidade de resolução, quando Leonhard Euler , em 1736, provou que não existia caminho que possibilitasse tais restrições.



- Topologia

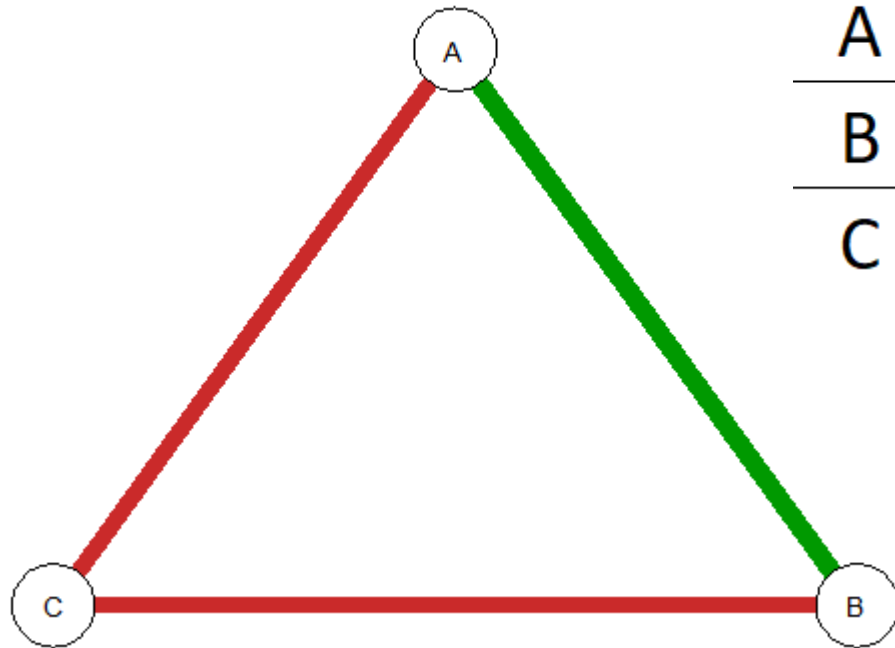
O que é uma rede?

- Vértices (nodos) e arestas (linhas)
- Nodos representam variáveis
- As linhas representam a relação entre os nodos

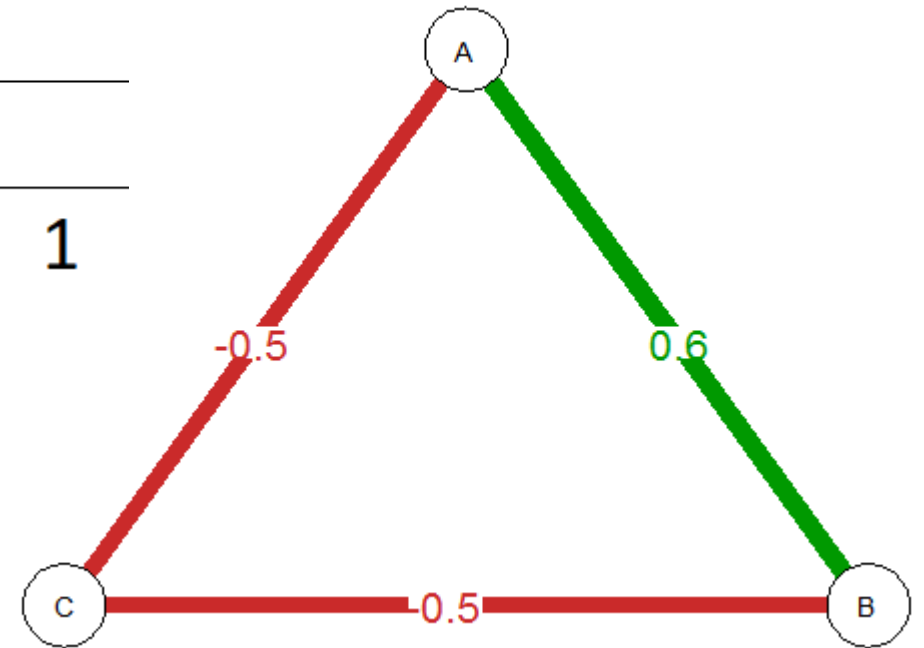


Medidas de associação entre variáveis

- Relação entre bem-estar (A), suporte social (B) e depressão (C)



	A	B	C
A	1		
B	0,6	1	
C	-0,5	-0,5	1



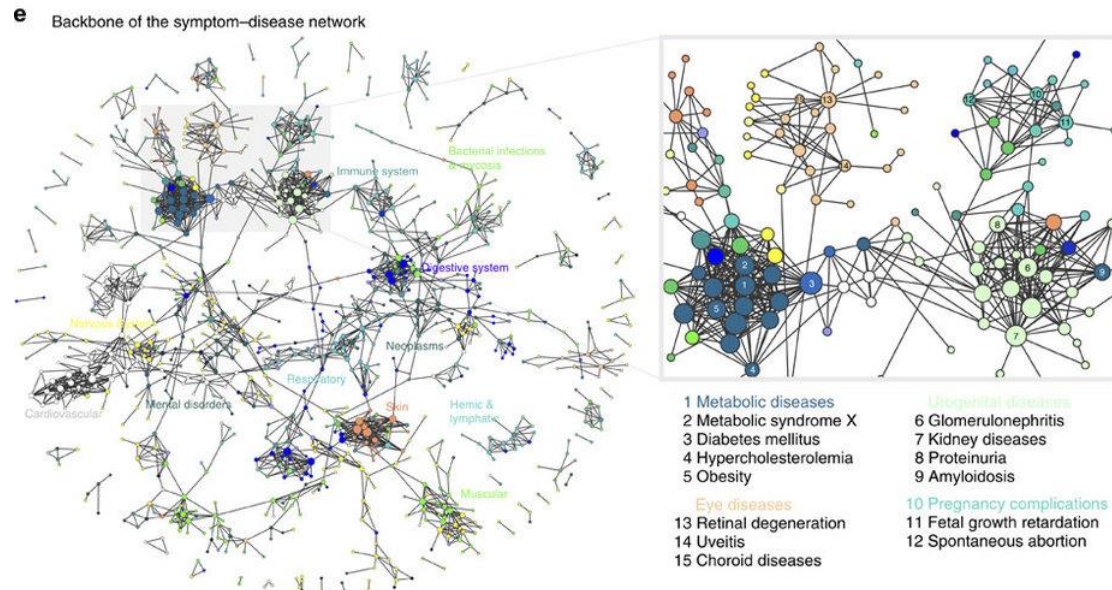
Article

Human symptoms–disease network

XueZhong Zhou✉, Jörg Menche, Albert-László Barabási & Amitabh Sharma✉

Nature Communications 5,
Article number: 4212 (2014)
doi:10.1038/ncomms5212


Received: 07 November 2013
Accepted: 27 May 2014
Published online: 26 June 2014

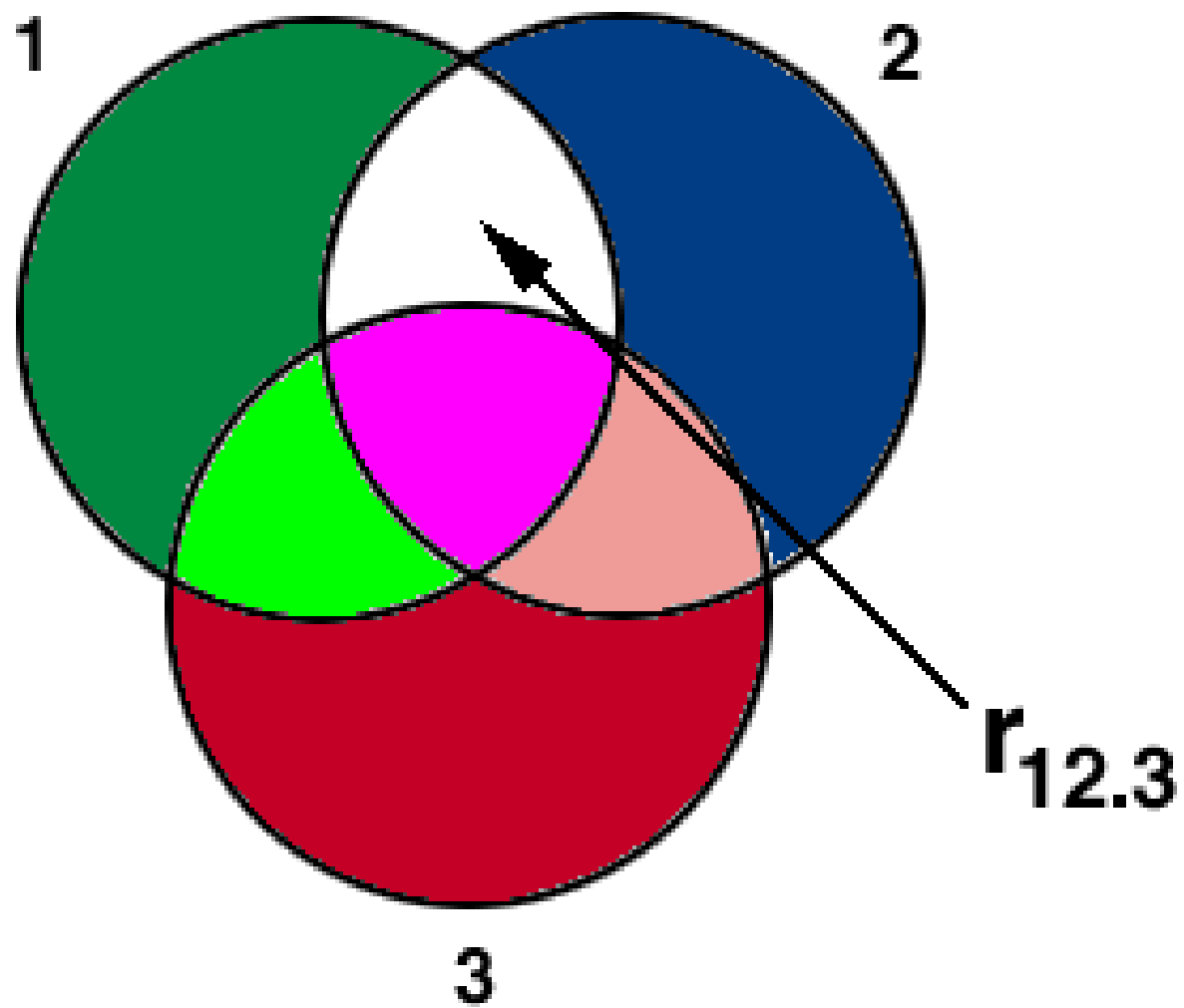


We extracted **7,109,429** (about 35.5% in over twenty million records) PubMed bibliographic records with one or more disease/symptom terms in the MeSH metadata field (see Methods), yielding a total of 4,442 disease terms and 322 symptom terms

Exemplos no script com a subescala depressão da DASS21

- RStudio

 Universidade Federal de São Paulo Campus Baixada Santista					
<i>Programa de Pós-Graduação Interdisciplinar em Ciências da Saúde</i>					
DASS – 21 Versão traduzida e validada para o português do Brasil Autores: Vignola, R.C.B. & Tucci, A.M.					
Instruções Por favor, leia cuidadosamente cada uma das afirmações abaixo e circule o número apropriado 0,1,2 ou 3 que indique o quanto ela se aplicou a você durante a última semana, conforme a indicação a seguir:					
0	Não se aplicou de maneira alguma				
1	Aplicou-se em algum grau, ou por pouco de tempo				
2	Aplicou-se em um grau considerável, ou por uma boa parte do tempo				
3	Aplicou-se muito, ou na maioria do tempo				
1	Achei difícil me acalmar	0	1	2	3
2	Senti minha boca seca	0	1	2	3
3	Não consegui vivenciar nenhum sentimento positivo	0	1	2	3

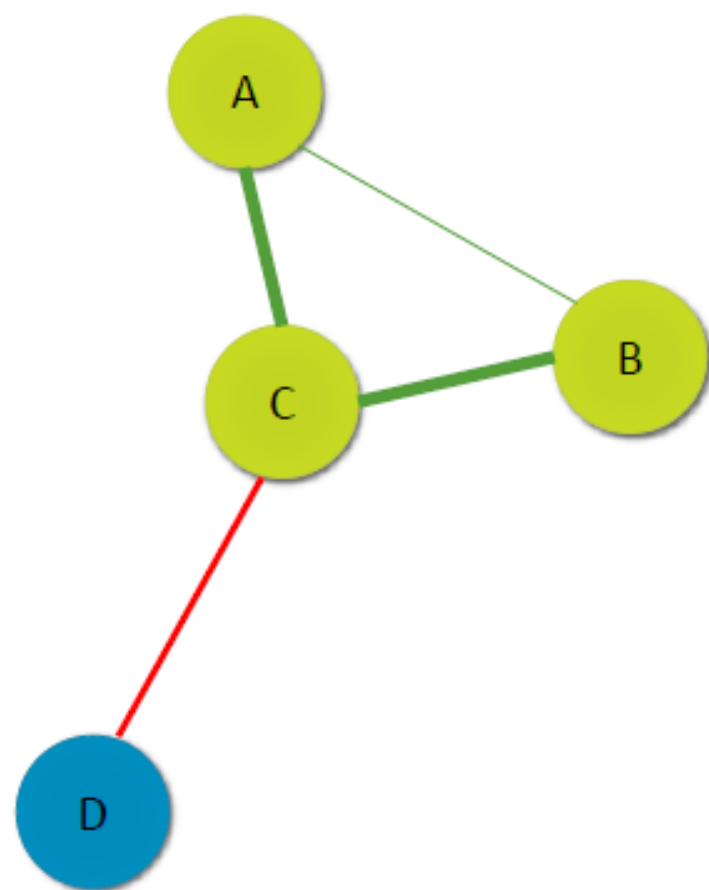


Regressão parcial (semiparcial)

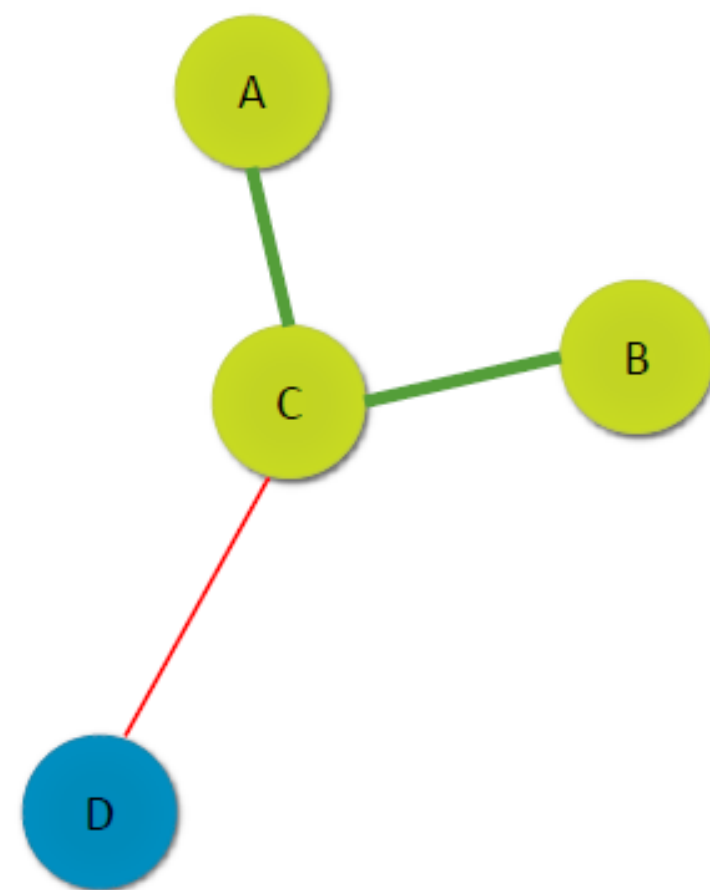
- Regressão Linear Múltipla
- AFE – matriz de precisão (correlações parciais)
- Problema da esparcialidade

GeLasso estimation

- Graphical LASSO – (least absolute shrinkage and selection operator)
- Parâmetro de ajuste para o controle da esparsidade (fixa em zero as arestas com pesos muito pequenos, próximos à zero), chamado λ
- São testados, por default, 100 valores de λ
- A seleção do modelo com menor resíduo é feita por meio do Extended Bayesian Criteria (EBIC), que penaliza modelos complexos (muitas arestas), chamado hiperparâmetro γ . Se $\gamma = 0$, o método é o BIC.



*Rede esparsa, na qual os
valores de baixa magnitude
são fixados em zero*



Friedman, Hastie & Tibshirani (2008)

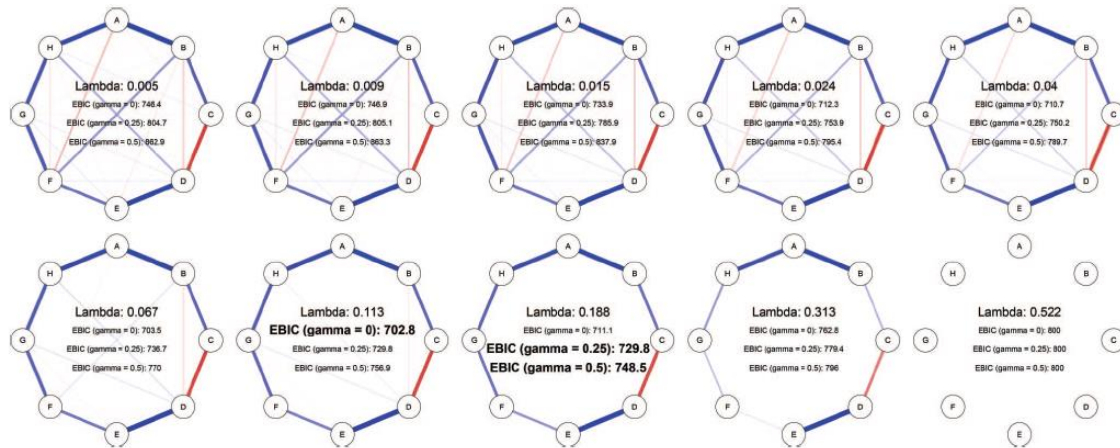


Figure 2. Ten different partial correlation networks estimated using lasso regularization. Setting the lasso tuning parameter λ that controls sparsity leads to networks ranging from densely connected to fully unconnected. Data were simulated under the network represented in Figure 1. The fit of every network was assessed using the EBIC, using hyperparameter γ set to 0, 0.25 or 0.5. The bold-faced EBIC value is the best, indicating the network which would be selected and returned using that γ value. See the online article for the color version of this figure.

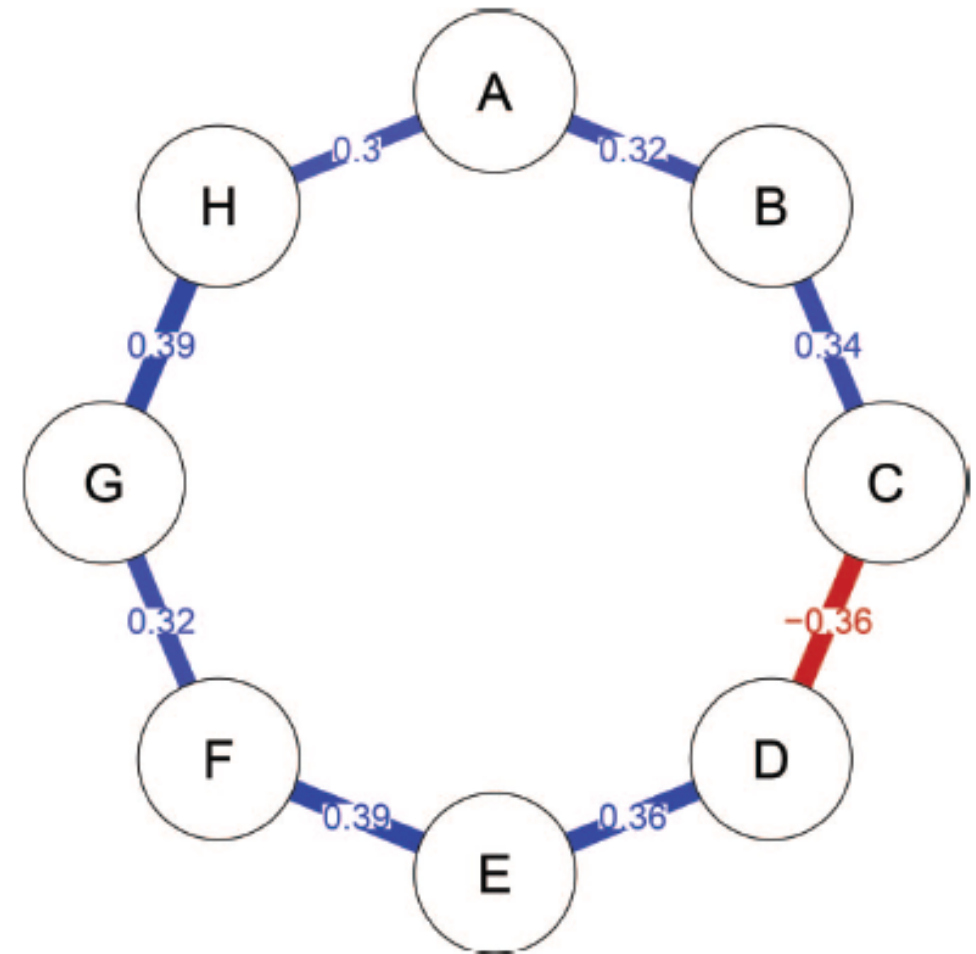


Figure 1. True network structure used in simulation example. The network represents a *partial correlation network*: nodes represent observed variables and edges represent partial correlations between two variables after conditioning on all other variables. The simulated structure is a *chain graph* in which all absolute partial correlation coefficients were drawn randomly between 0.3 and 0.4. See the online article for the color version of this figure.



AMERICAN
PSYCHOLOGICAL
ASSOCIATION

Psychological Methods

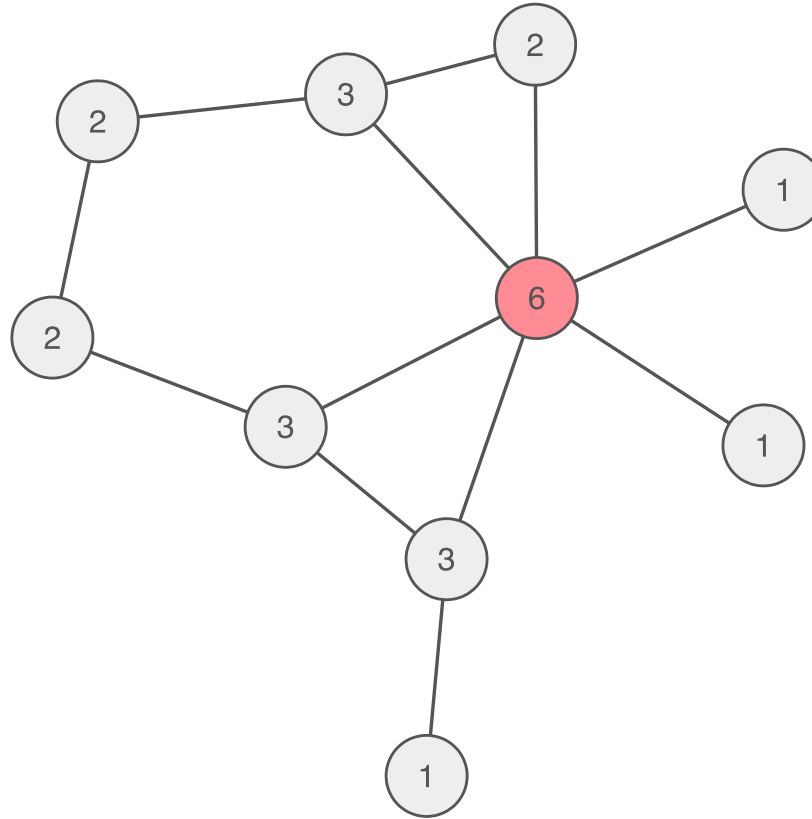
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1082-989X/18/\$12.00

<http://dx.doi.org/10.1037/met0000167>

A Tutorial on Regularized Partial Correlation Networks

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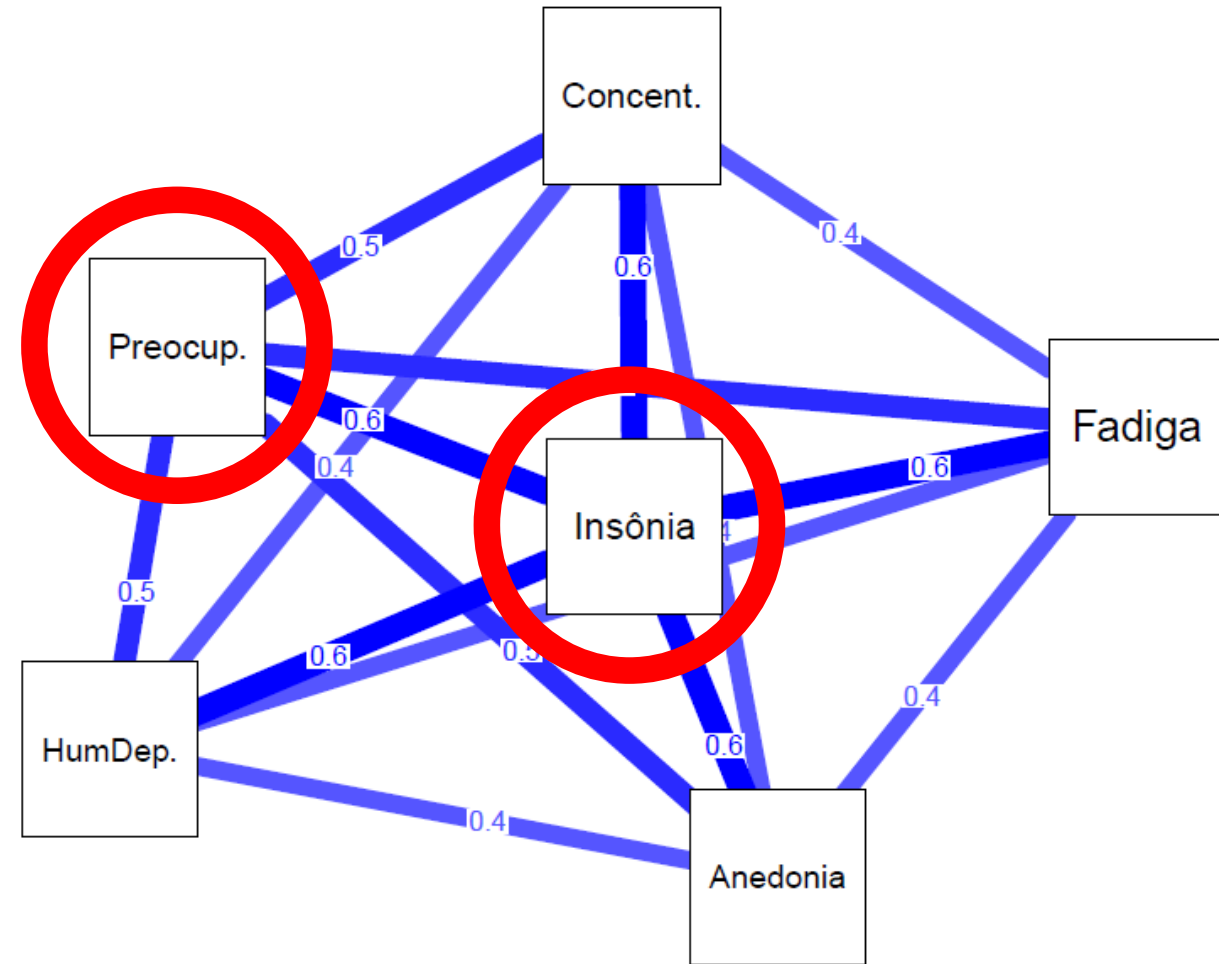
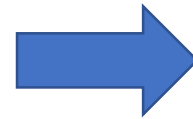
Centralidade



Opsahl, T., Agneessens, F., & Skvoretz, J. (2010). Node centrality in weighted networks: Generalizing degree and shortest paths. *Social Networks*, 23, 245-251.

Depressão: estrutura e dinâmica de um sistema

	Insônia	Fadiga	Concent.	Preocup.	HumDep.	Anedonia
Insônia	1.0	0.6	0.6	0.6	0.6	0.6
Fadiga	0.6	1.0	0.4	0.5	0.4	0.4
Concent.	0.6	0.4	1.0	0.5	0.4	0.4
Preocup.	0.6	0.5	0.5	1.0	0.5	0.5
HumDep.	0.6	0.4	0.4	0.5	1.0	0.4
Anedonia	0.6	0.4	0.4	0.5	0.4	1.0



Centralidade

- Força (strength): soma modular ponderada das arestas de um nodo
- Proximidade (closeness): distância dos vértices adjacentes (inverso da distância)
- Conectividade (betweenness): vezes pelas quais o vértice é a menor distância (shortest path) entre outros dois vértices

Opsahl, T., Agneessens, F., & Skvoretz, J. (2010). Node centrality in weighted networks: Generalizing degree and shortest paths. *Social Networks*, 23, 245-251.

Expected Influence

- Influência esperada: soma das arestas dos nodos adjacentes em primeiro e segundo graus



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Identifying Highly Influential Nodes in the Complicated Grief Network

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²Harvard Medical School

³Department of Psychology, Harvard University

Exemplos com todos os itens da DASS21

- RStudio



Universidade Federal de São Paulo
Campus Baixada Santista

Programa de Pós-Graduação Interdisciplinar em Ciências da Saúde

DASS – 21 Versão traduzida e validada para o português do Brasil
Autores: Vignola, R.C.B. & Tucci, A.M.

Instruções
Por favor, leia cuidadosamente cada uma das afirmações abaixo e circule o número apropriado **0,1,2 ou 3** que indique o quanto ela se aplicou a você durante a última semana, conforme a indicação a seguir:

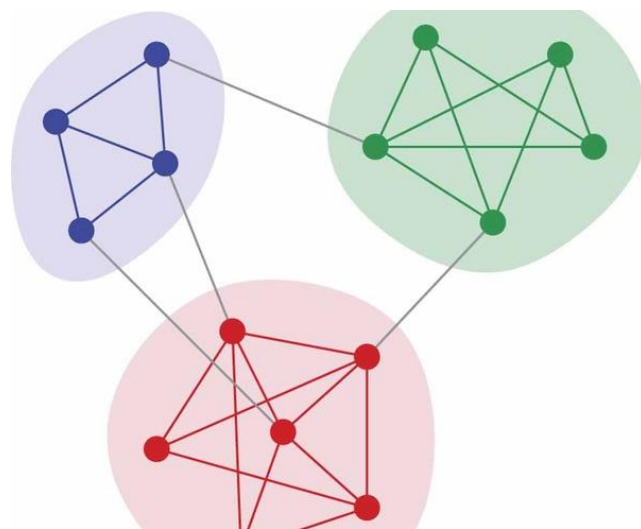
0 Não se aplicou de maneira alguma

1 Aplicou-se em algum grau, ou por pouco de tempo

2 Aplicou-se em um grau considerável, ou por uma boa parte do tempo


3 Aplicou-se muito, ou na maioria do tempo

1	Achei difícil me acalmar	0	1	2	3
2	Senti minha boca seca	0	1	2	3
3	Não consegui vivenciar nenhum sentimento positivo	0	1	2	3



Article | [OPEN](#)

A Comparative Analysis of Community Detection Algorithms on Artificial Networks

Zhao Yang , René Algesheimer & Claudio J. Tessone

Scientific Reports 6, Article number: 30750
(2016)
doi:10.1038/srep30750

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Análise de comunidades

- Existem subgrupos de variáveis ou observações na rede?
- Três métodos mais populares:
- Waltrap – parte de passos aleatórios e vai decompondo o conjunto em N-1 comunidades, calculando a distância das arestas entre e dentro comunidades
- Spinglass – baseado também em um modelo do ferromagnetismo (Potts), baseado na ideia de “spin state” e fluxo de energia
- **Multinível** – decomposição e permutação dos vértices até encontrar a solução que otimiza a modularidade (divisão em módulos ou grupos)

RESEARCH ARTICLE

Exploratory graph analysis: A new approach for estimating the number of dimensions in psychological research

Hudson F. Golino^{1,2*}, Sacha Epskamp³

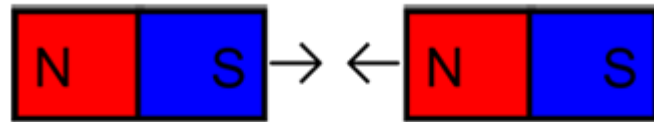
Exemplo com dados dicotômicos/binários

- Ising Model e TRI multidimensional

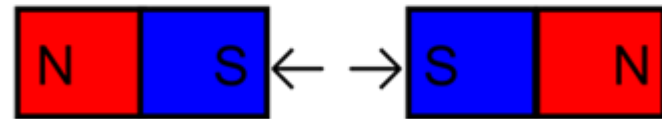


Ising model

- Estudo do ferromagnetismo



Opposite poles **attract**



Same poles **repel**

OPEN

A new method for constructing networks from binary data

SUBJECT AREAS:

PSYCHOLOGY
SIGNS AND SYMPTOMS

Claudia D. van Borkulo^{1,2}, Denny Borsboom², Sacha Epskamp², Tessa F. Blanken², Lynn Boschloo¹, Robert A. Schoevers¹ & Lourens J. Waldorp²

$$\mathbb{P}_{\Theta}(x_j | x_{\setminus j}) = \frac{\exp \left[\tau_j x_j + x_j \sum_{k \in V_{\setminus j}} \beta_{jk} x_k \right]}{1 + \exp \left[\tau_j + \sum_{k \in V_{\setminus j}} \beta_{jk} x_k \right]}, \quad (1)$$

where τ_j and β_{jk} are the node parameter (or threshold) and the pairwise interaction parameter respectively.

OPEN Three representations of the Ising model

Joost Kruis¹ & Gunter Maris^{1,2}

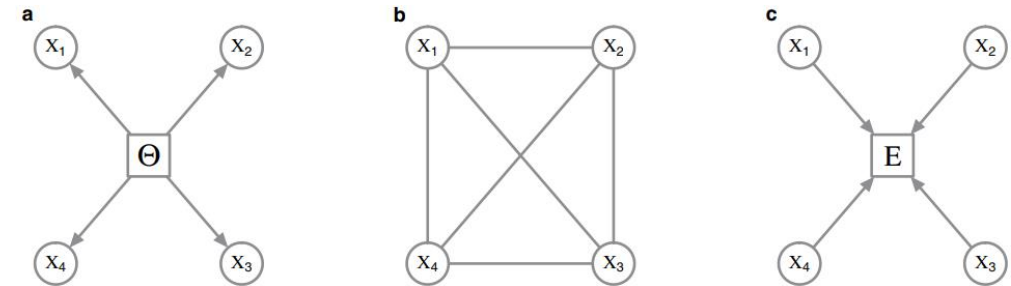


Figure 1. Three frameworks for explaining observed associations in the parametrization of their prototypical statistical models. (a) The Rasch model from the common cause framework as a DAG. (b) The Curie-Weiss model from the reciprocal affect framework as an undirected graph. (c) The collider selection bias model from the common effect framework as a DAG.

The relation between the Ising model and item response theory

In this section we will show that the Ising model is closely related to the modeling framework of IRT, which is of central importance to psychometrics. In fact, we will show that the Ising model is equivalent to a special case of the multivariate two-parameter logistic model (MIRT). However, instead of being hypothesized common causes of the item responses, in our representation the latent variables in the model are *generated* by cliques in the network.

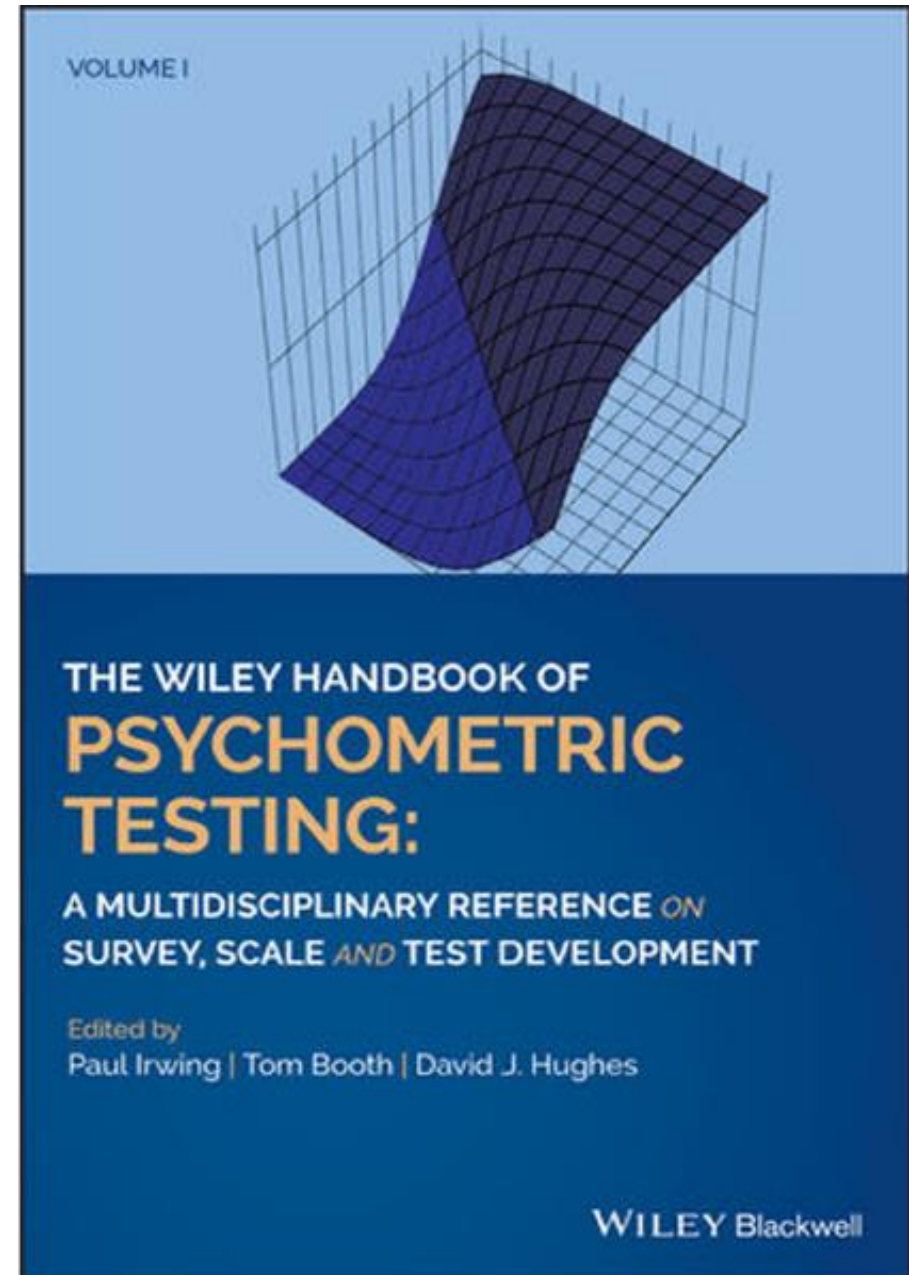
In IRT, the responses on a set of binary variables X are assumed to be determined by a set of M ($M \leq P$) latent variables $\Theta^\top = [\Theta_1 \Theta_2 \dots \Theta_M]$. These latent variables are often termed *abilities*, which betrays the roots of the model in educational testing. In IRT, the probability of obtaining a realization x_i on the variable X_i —often called *items*—is modeled through item response functions, which model the probability of obtaining one of the two possible responses (typically, scored 1 for correct responses and 0 for incorrect responses) as a function of θ . For instance, in the (Rasch, 1960) model, also called the one-parameter logistic model (1PL), only one latent trait is assumed ($M = 1$ and $\Theta = \theta$) and the conditional probability of a response given the latent trait takes the form of a simple logistic function:

$$\Pr(X_i = x_i \mid \Theta = \theta)_{1PL} = \frac{\exp(x_i \alpha (\theta - \delta_i))}{\sum_{x_i} \exp(x_i \alpha (\theta - \delta_i))},$$

30

Network Psychometrics

Sacha Epskamp, Gunter Maris, Lourens J. Waldorp,
and Denny Borsboom



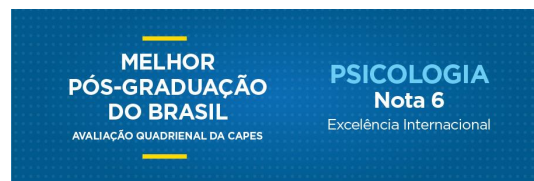
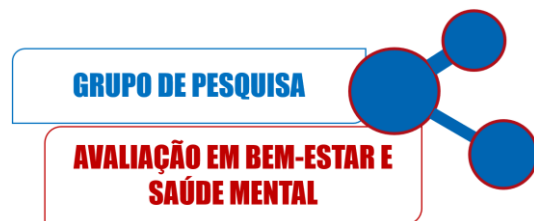
Parâmetros do modelo

- Interação par a par (pairwise interaction) via regressão logística com covariáveis (β)
- Parâmetro do item (τ)
- Exemplo no RStudio



Direções futuras

- Modelos de dados mistos (mixed network)
- Interações 3-way
- Redes com variáveis latentes
- ?



NETWORK PSYCHOMETRICS

uma introdução

OBRIGADO!!!

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