ESCOLA DE CIÊNCIAS DA SAÚDE
PUCRS

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

Network Analysis?

Análise de rede aplicada à psicometria e a avaliação psicológica

Wagner de Lara Machado

Pontifícia Universidade Católica de Campinas

João Ricardo Nickenig Vissoci

Faculdade Ingá e Duke University

Sacha Epskamp

Universiteit van Amsterdam

Sacha Epskamp
Assistant Professor in Psychological Methods and Psychometrics at the University of 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

(vii)
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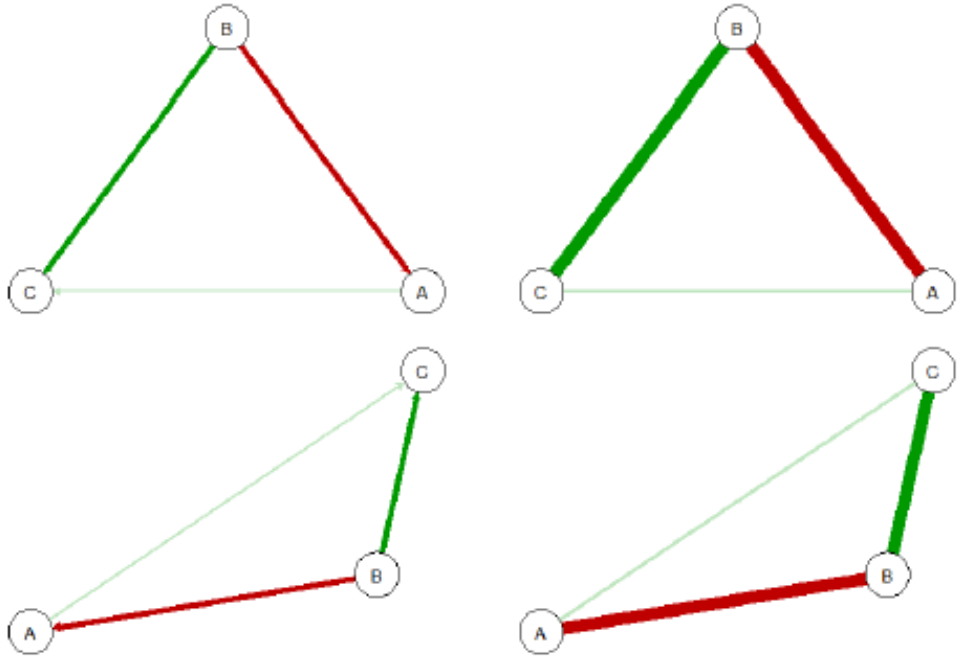


Figura 5. Redes ponderadas, direcionais e não-direcionais, sem (acima) e com (abaixo) o emprego do algoritmo de posicionamento.

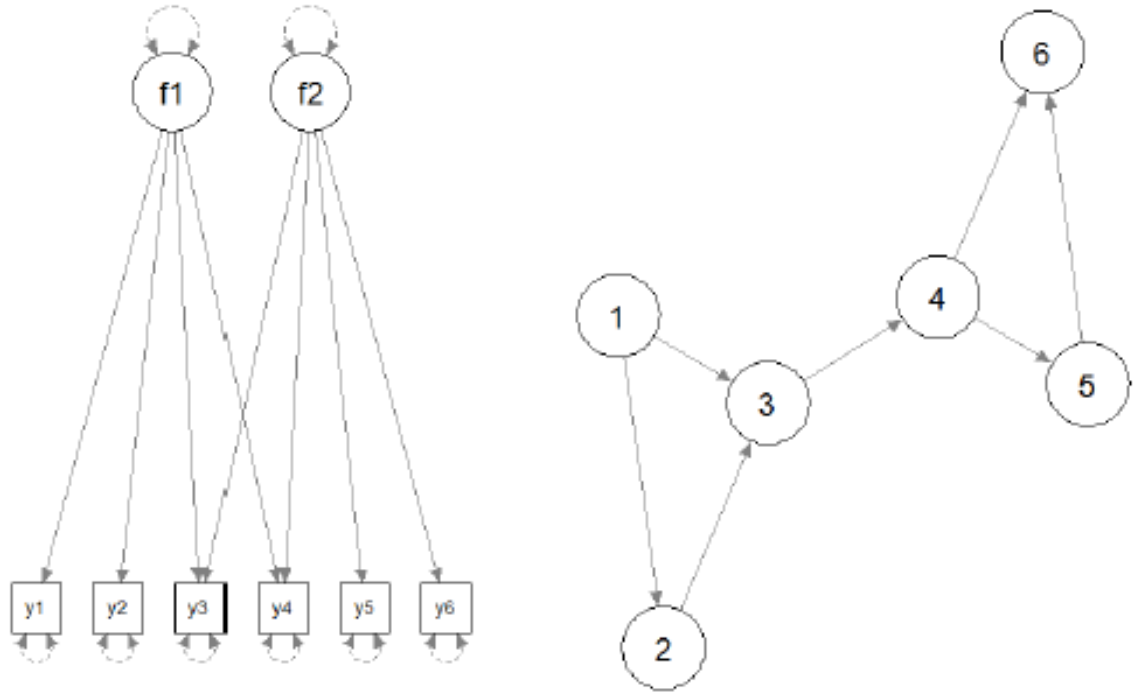


Figura 13. Modelo de traço latente (esquerda) e de rede (direita) da comorbidade.

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

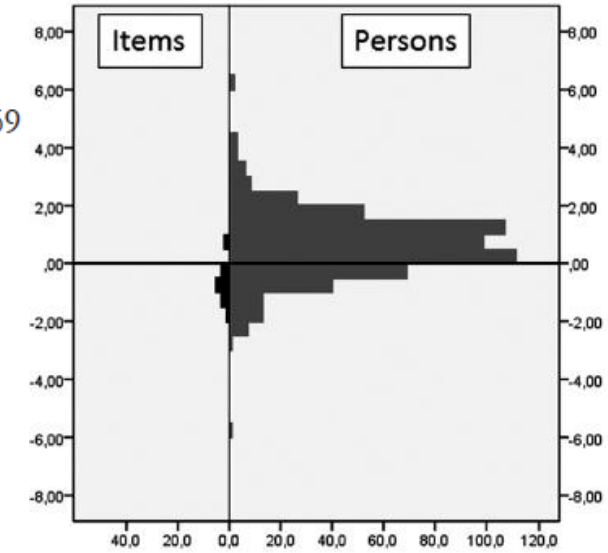


Figure 1. Map of items and persons. The vertical axis indicates the scale in *logits*. The distribution was obtained by fixing the contrary measure so the mean would be equal to zero.

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.

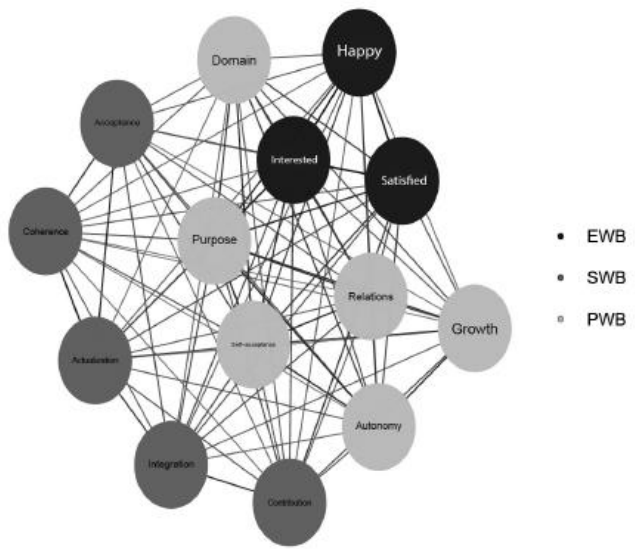


Figure 2. Network of positive mental health indicators. The covariance structure indicates that the MHC-SF items are strongly associated with the others, resulting in a dense component. The items in the emotional (EWB), social (SWB) and psychological (PWB) well-being subscales exhibit moderate to strong 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" ($r_{1\text{-}3}$ = .78); the fainter line represents the correlation between "relations" and "coherence" ($r_{8\text{-}11}$ = .35).

frontiers in Psychology

ORIGINAL RESEARCH
published: 22 February 2017
doi: 10.3389/fpsyg.2017.00192

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 Pasley[2], Wagner de Lara Machado[3], Ernesto Alvarado[4], Luciana Dutra-Thomé[4] and Silvia Helena Koller[4]*

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

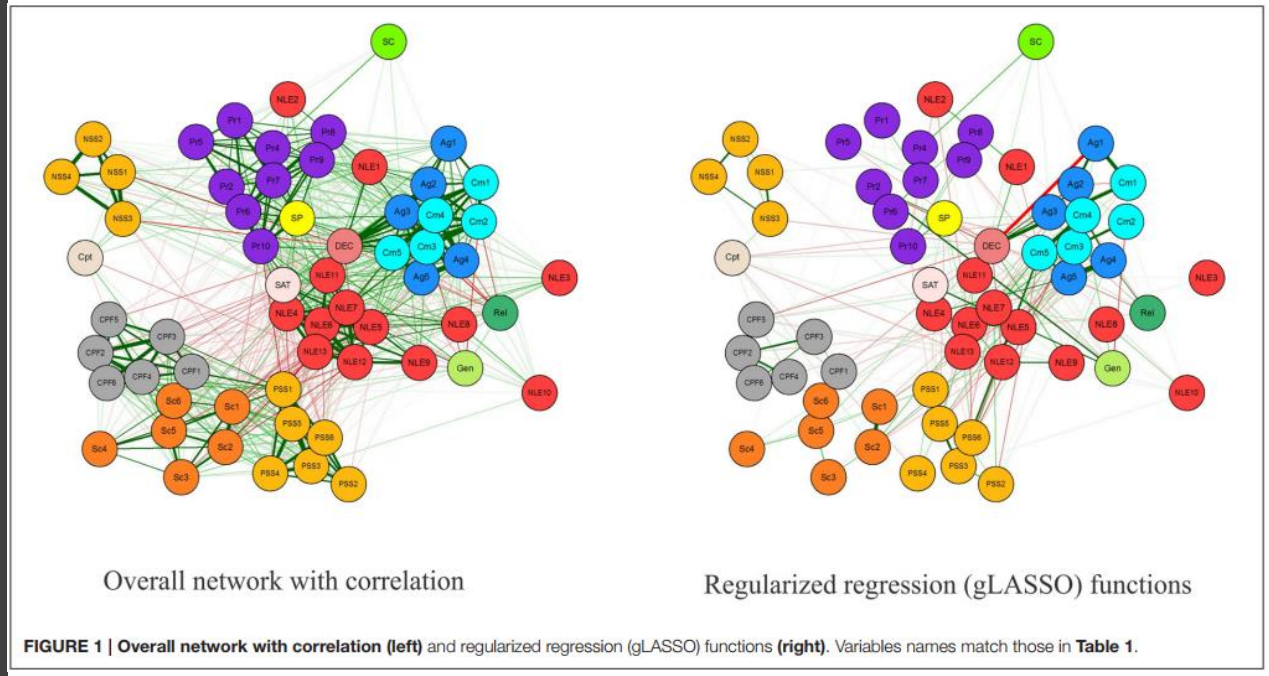
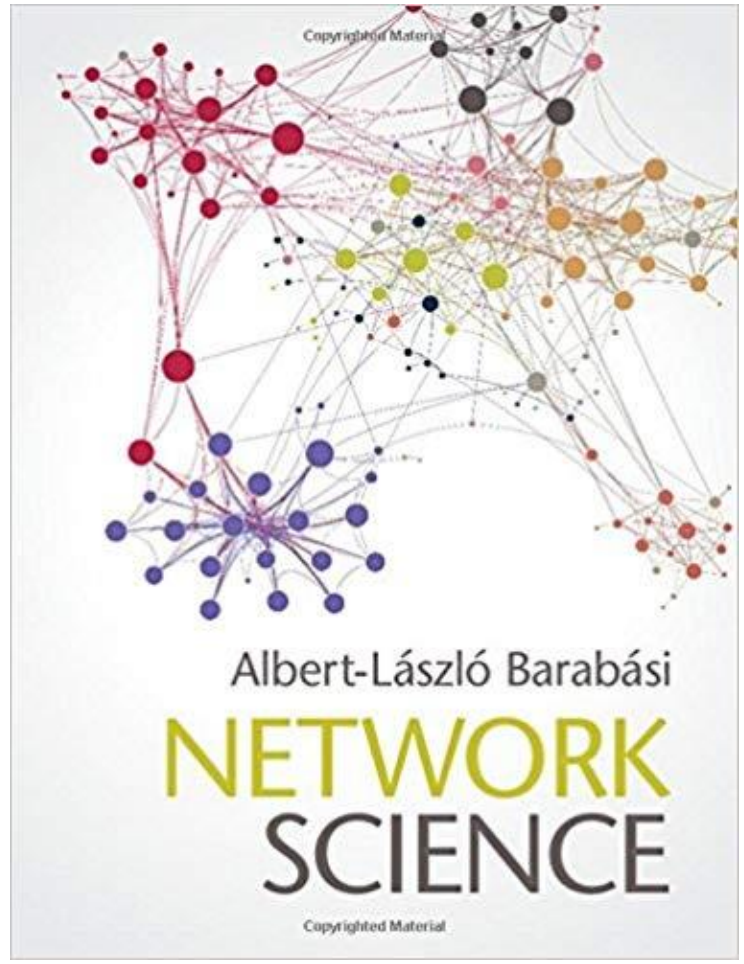


FIGURE 1 | Overall network with correlation (left) and regularized regression (gLASSO) functions **(right)**. Variables names match those in **Table 1**.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NETWORK
SCIENCE
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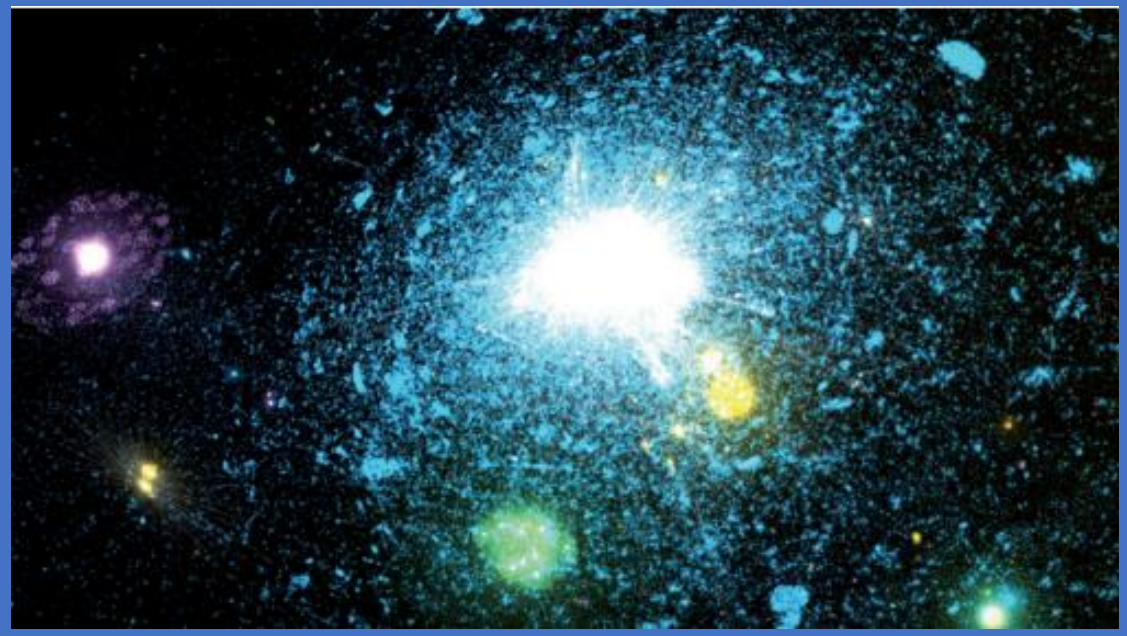
“Reductionism, as a paradigm, is expired, and complexity, as a field, is tired. Data-based mathematical models of complex systems are offering a fresh perspective, rapidly developing into a new discipline: network science.”

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

JOURNAL OF CLINICAL PSYCHOLOGY, Vol. 64(9), 1089–1108 (2008)

Published online in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/jclp.20503

Psychometric Perspectives on Diagnostic Systems

Denny Borsboom
University of Amsterdam

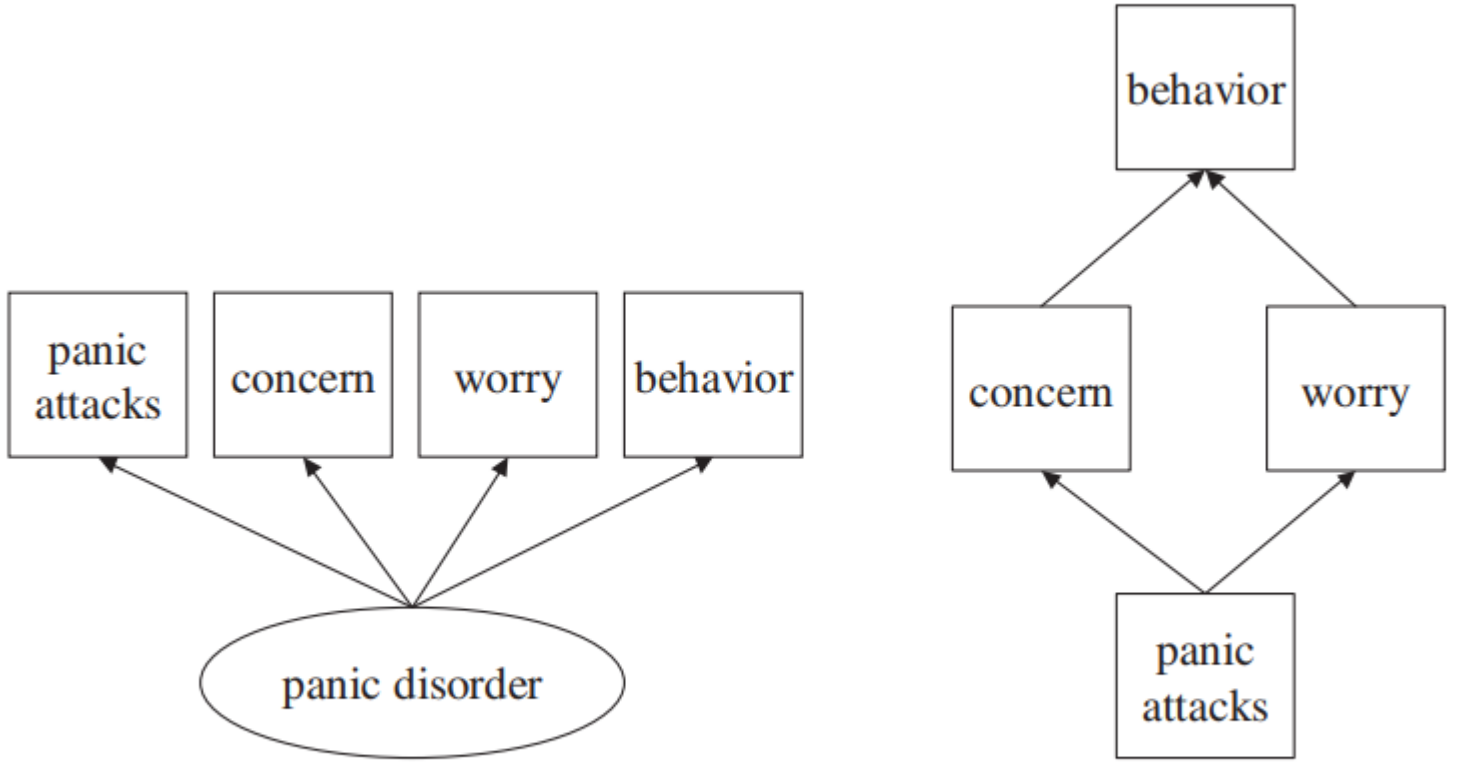


Figure 1. The left panel shows the relation between panic disorder and its symptoms from a latent variable modeling point of view. The right panel shows a representation of these symptoms as a causal system.

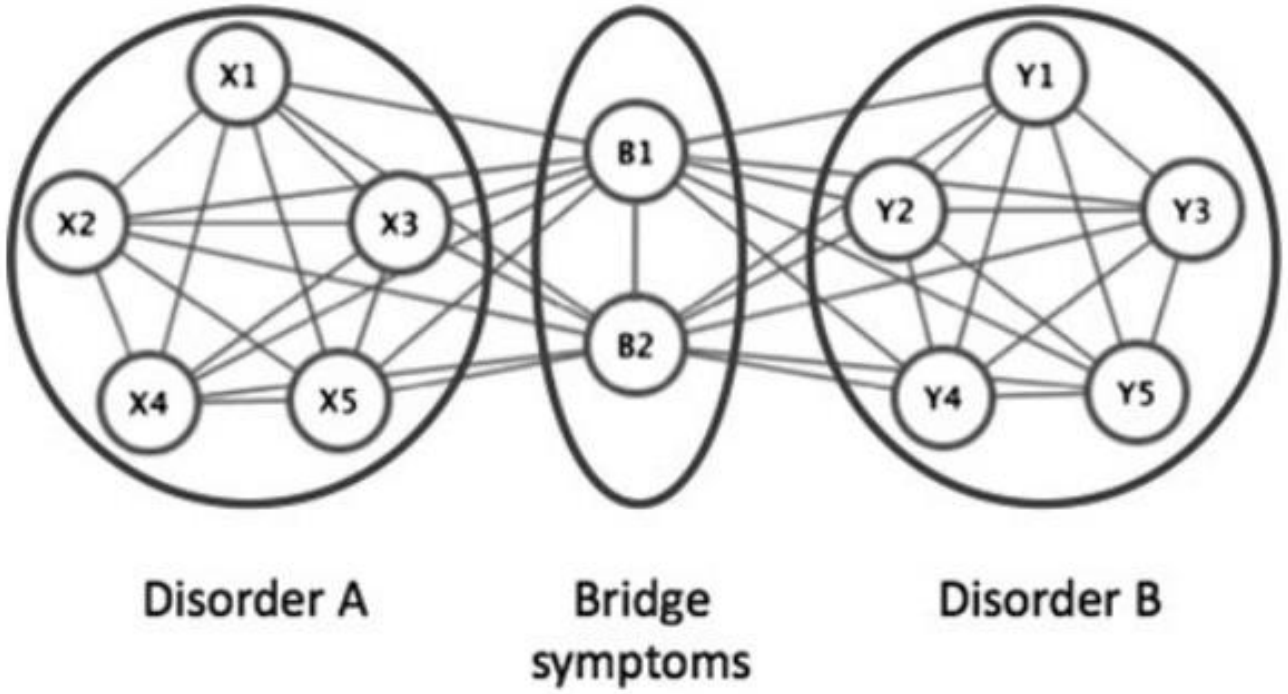


Figure 2. Comorbidity under a network approach. Disorder A consists of bidirectionally related symptoms $X_1 - X_5$, and disorder B consists of symptoms $Y_1 - Y_5$. Symptoms B_1 and B_2 are *bridge symptoms* that overlap between disorders A and B. In this model, comorbidity arises as a result of direct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

BEHAVIORAL AND BRAIN SCIENCES (2010) **33**, 137–193
doi:10.1017/S0140525X09991567

Comorbidity: A network perspective

Angélique O. J. Cramer
Department of Psychology, University of Amsterdam, 1018 WB Amsterdam, The Netherlands
A.O.J.Cramer@uva.nl
www.aojcramer.com

Lourens J. Waldorp
Department of Psychology, University of Amsterdam, 1018 WB Amsterdam, The Netherlands
L.J.Waldorp@uva.nl
http://users.fmg.uva.nl/lwaldorp

Han L. J. van der Maas
Department of Psychology, University of Amsterdam, 1018 WB Amsterdam, The Netherlands
H.L.J.vanderMaas@uva.nl
http://users.fmg.uva.nl/hvandermaas/

Denny Borsboom
Department of Psychology, University of Amsterdam, 1018 WB Amsterdam, The Netherlands
D.Borsboom@uva.nl
http://sites.google.com/site/borsboomdenny/dennyborsboom

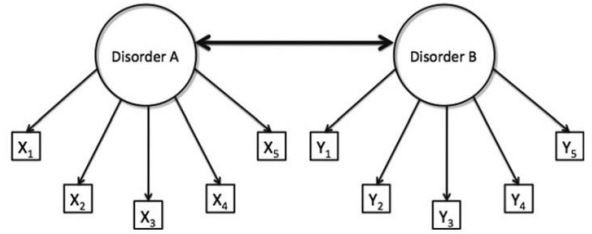


Figure 1. A model of comorbidity between disorders A and B, under the standard assumptions of latent variable modeling. The *circles* represent the disorders (i.e., latent variables) and the *rectangles* represent the observable core symptoms of those disorders (i.e., $X_1 - X_5$ for disorder A, and $Y_1 - Y_5$ 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.

OPEN ACCESS Freely available online

PLoS one

The Small World of Psychopathology

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

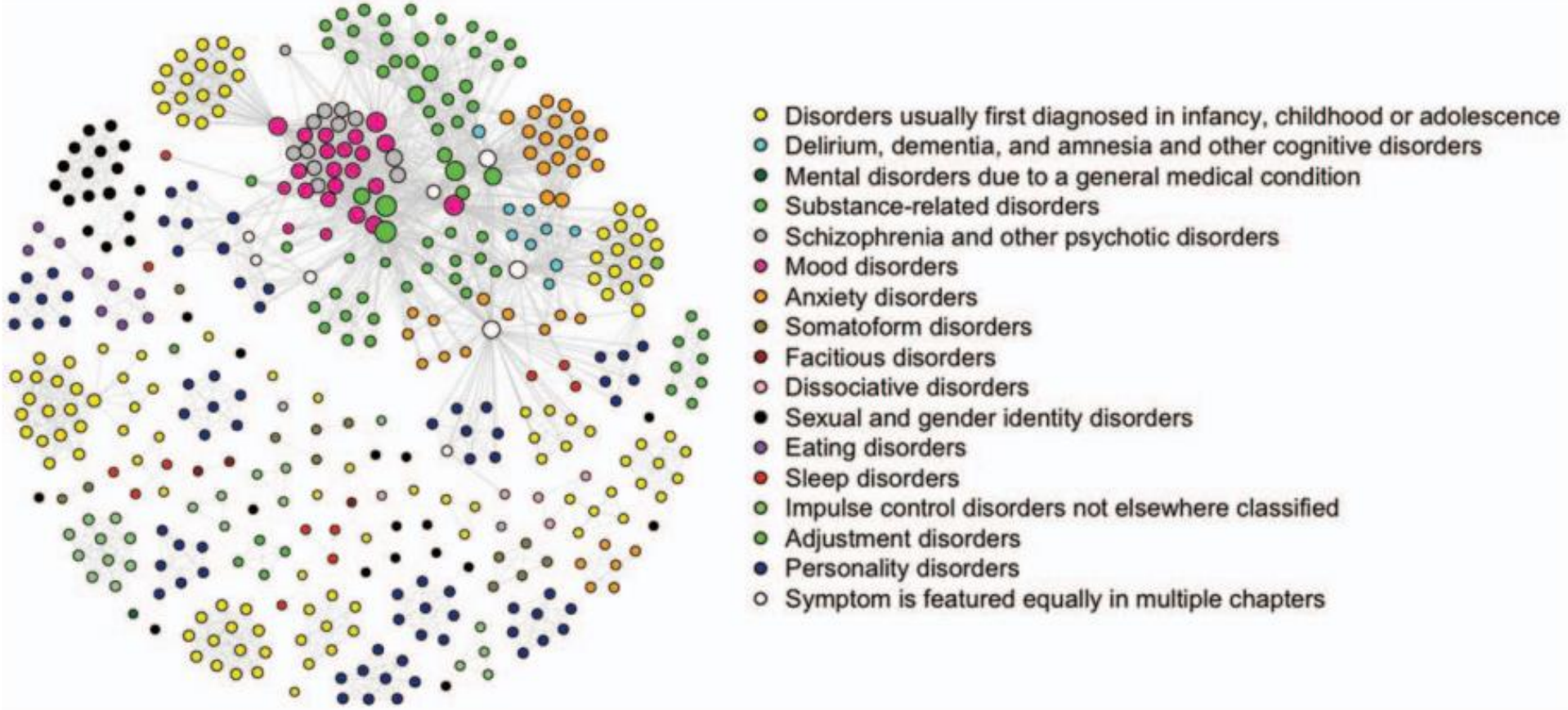


Figure 2. The DSM-IV symptom space. Symptoms are represented as nodes and connected by an edge whenever they figure in the same disorder. Color of nodes represents the DSM-IV chapter in which they occur most often.

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

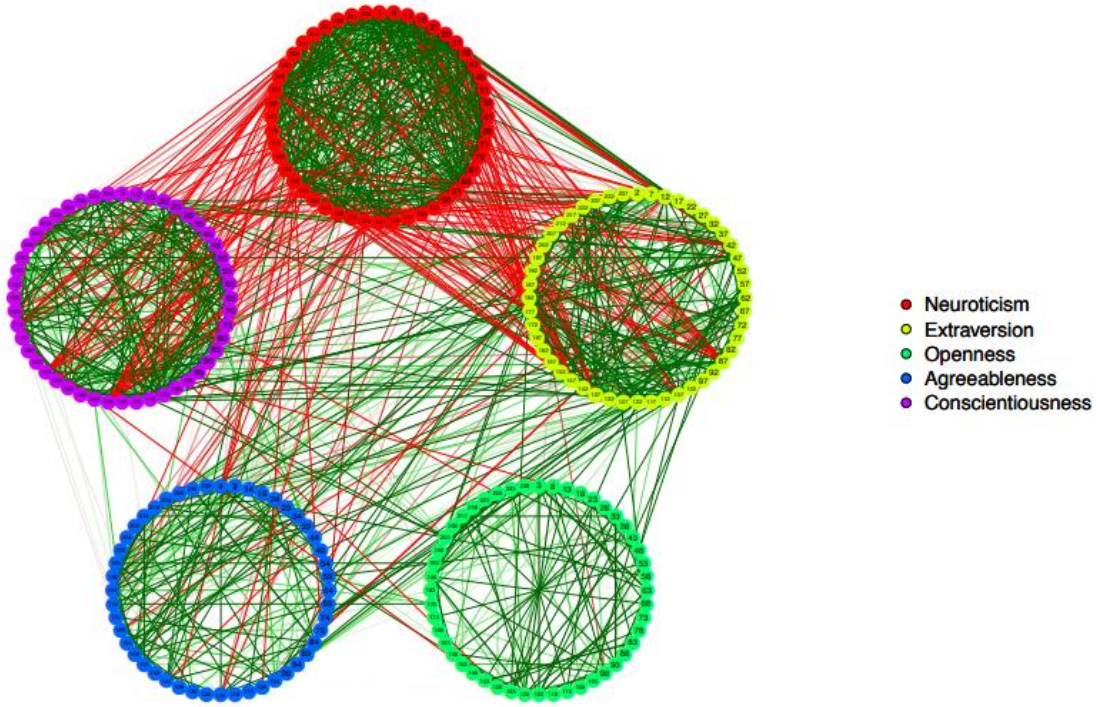
Sacha Epskamp
University of Amsterdam

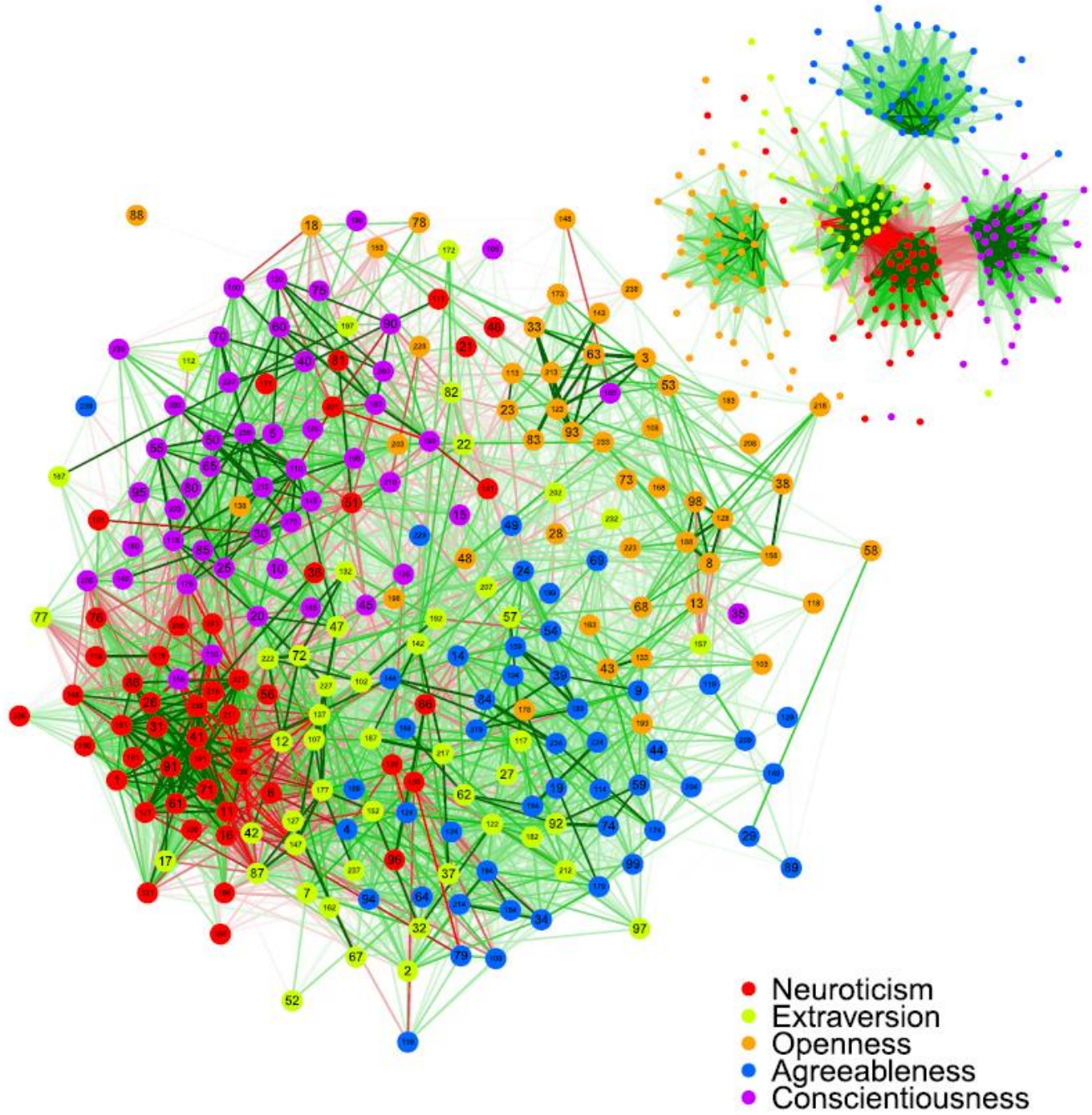
Angélique O. J. Cramer
University of Amsterdam

Lourens J. Waldorp
University of Amsterdam

Verena D. Schmittmann
University of Amsterdam

Denny Borsboom
University of Amsterdam




Neuroticism
Extraversion
Openness
Agreeableness
Conscientiousness

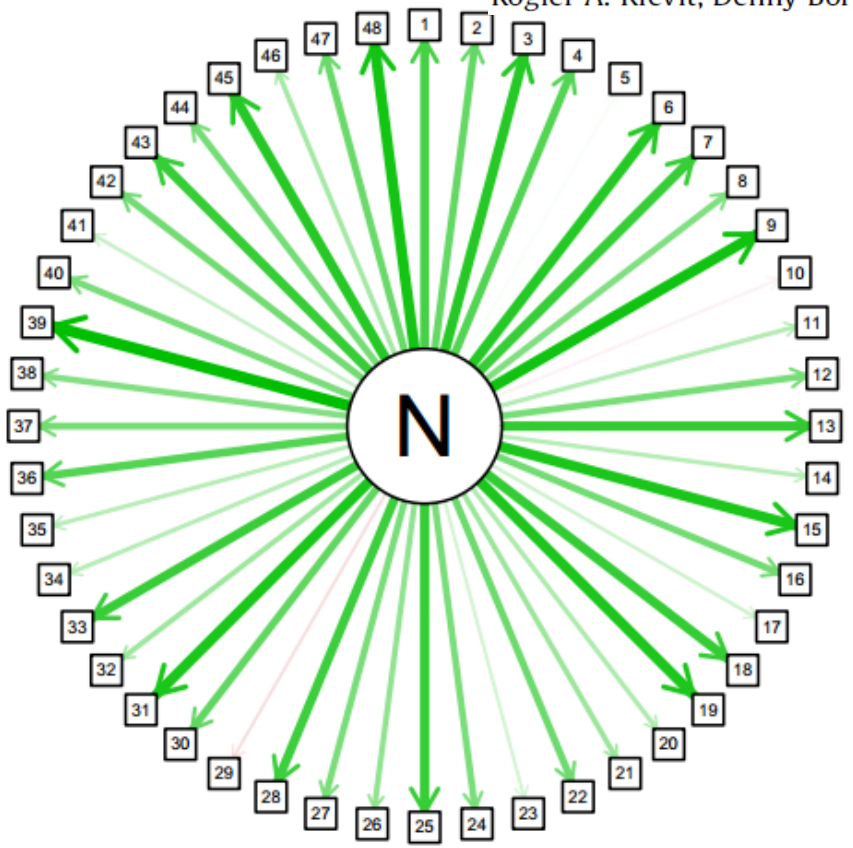
Contents lists available at ScienceDirect

New Ideas in Psychology

journal homepage: www.elsevier.com/locate/newideapsych

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*



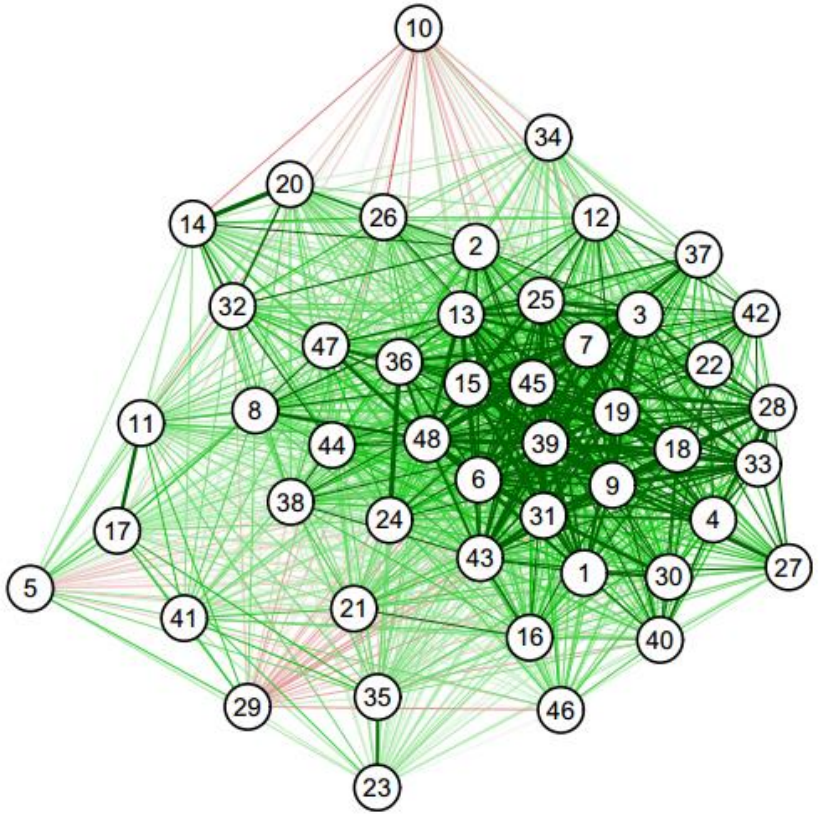


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Fig. 6. The best fitting confirmative time series model of the following five constituents of depression: tiredness; concentration difficulties (*concentration*); self-content; sad mood; pleasure in current activity (*activity*).

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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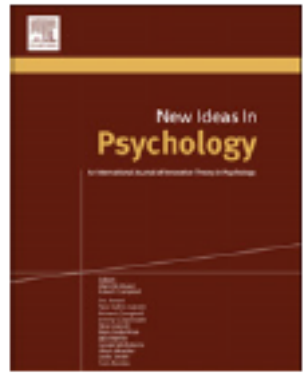
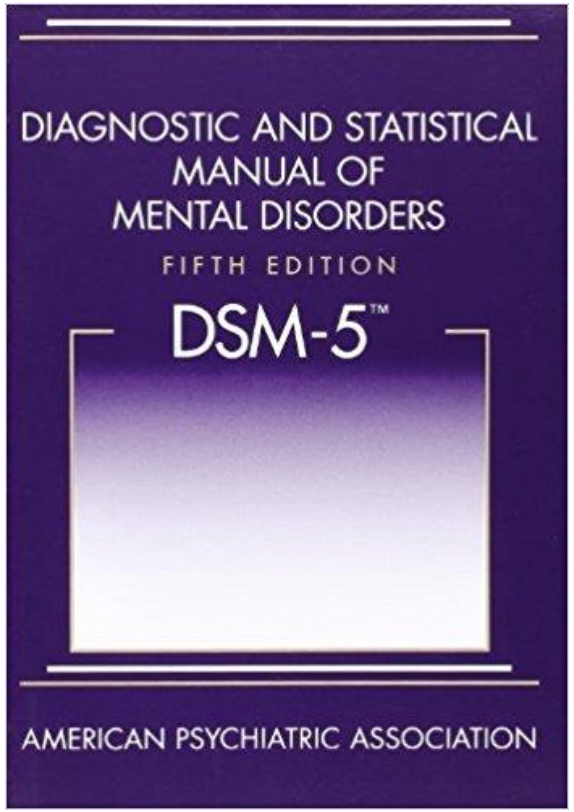


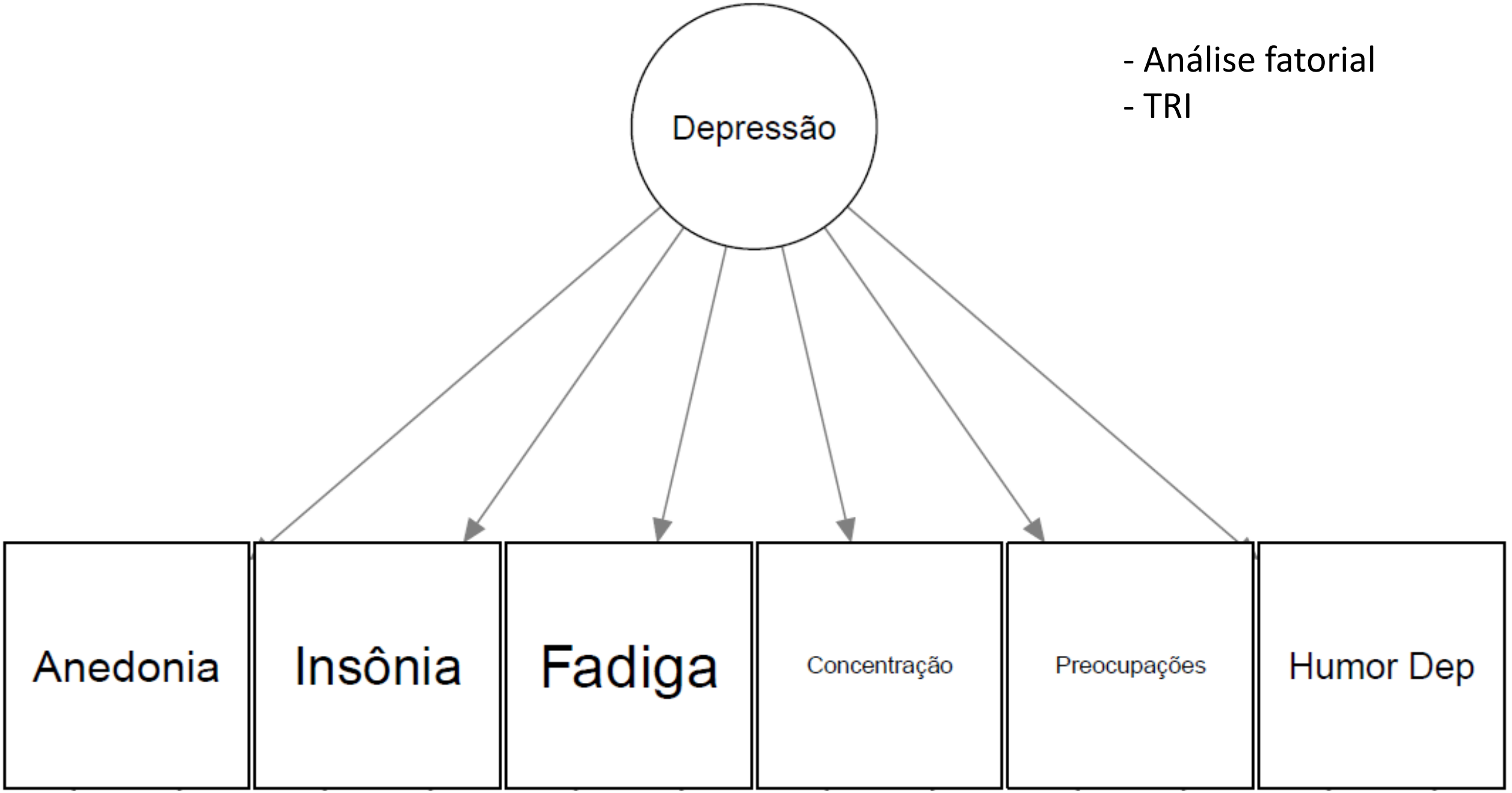
Deconstructing the construct: A network perspective on psychological phenomena

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

Psychological Assessment

1040-3590/16/$12.00 http://dx.doi.org/10.1037/pas0000275

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

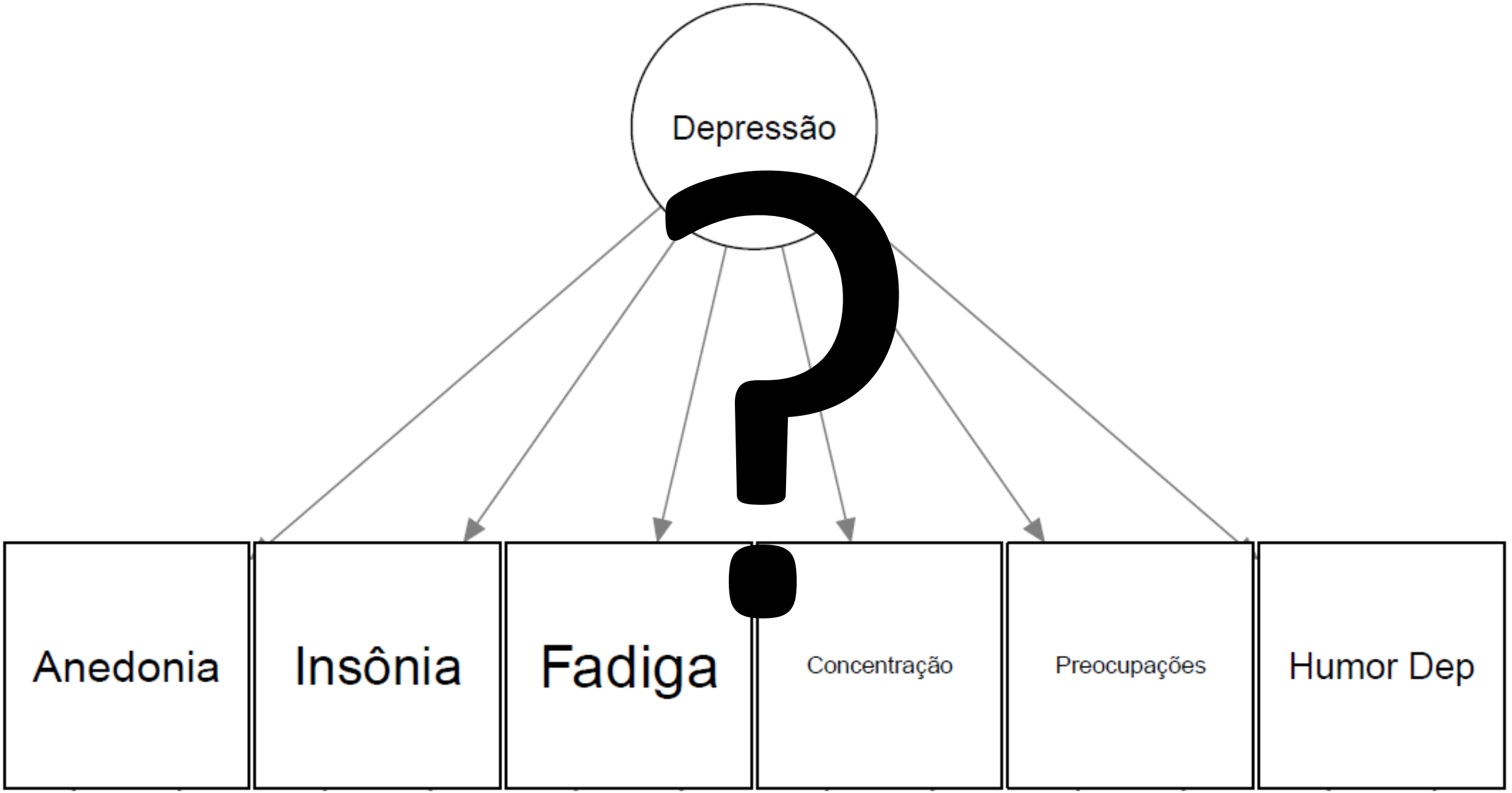
Claudia D. van Borkulo
University of Groningen and University of Amsterdam

Sacha Epskamp
University of Amsterdam

Robert A. Schoevers
University of Groningen

Francis Tuerlinckx
University of Leuven

Denny Borsboom
University of Amsterdam


Depressão
Anedonia
Insônia
Fadiga
Concentração
Preocupações
Humor Dep

Contents lists available at ScienceDirect

New Ideas in Psychology

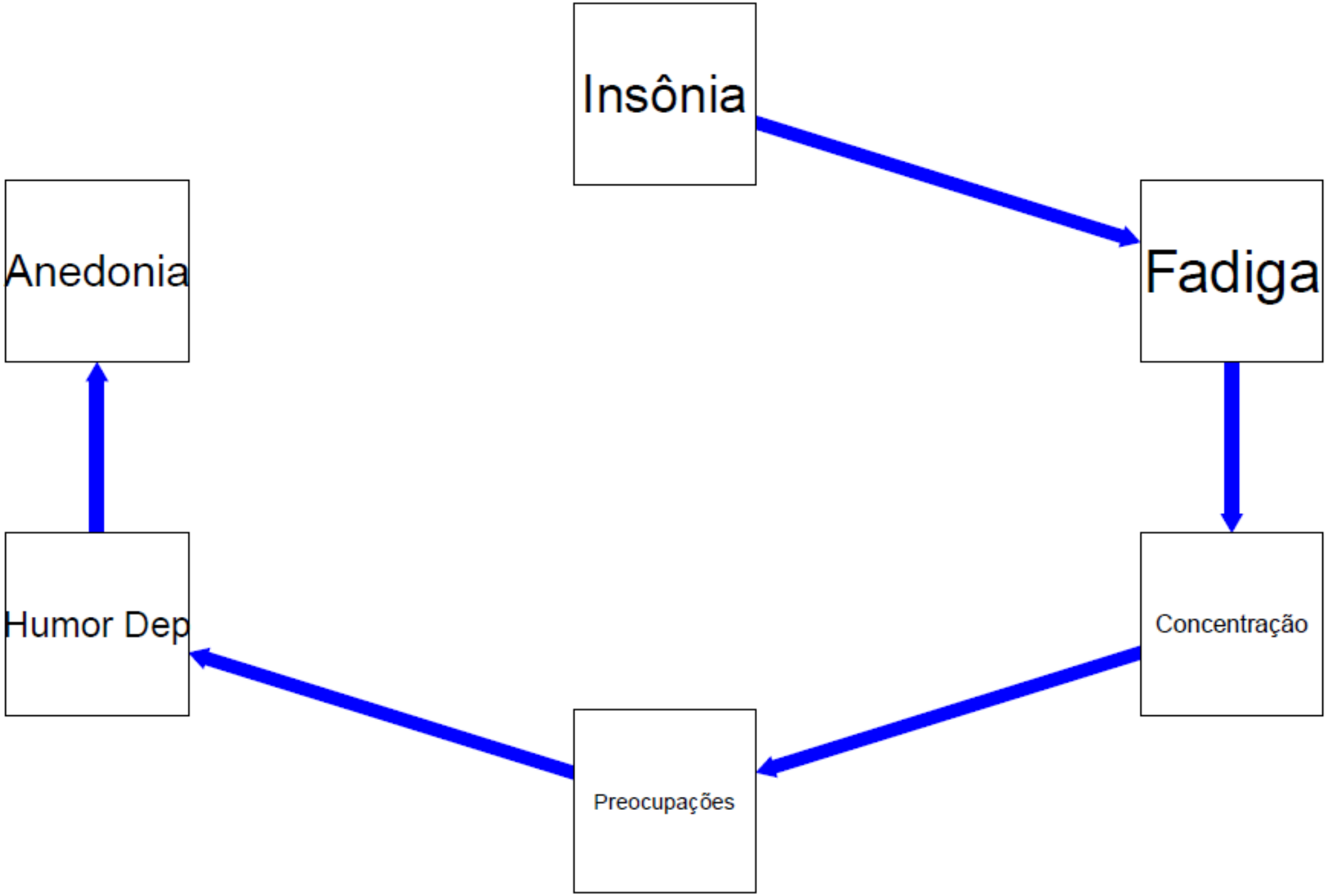
journal homepage: www.elsevier.com/locate/newideapsych

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*

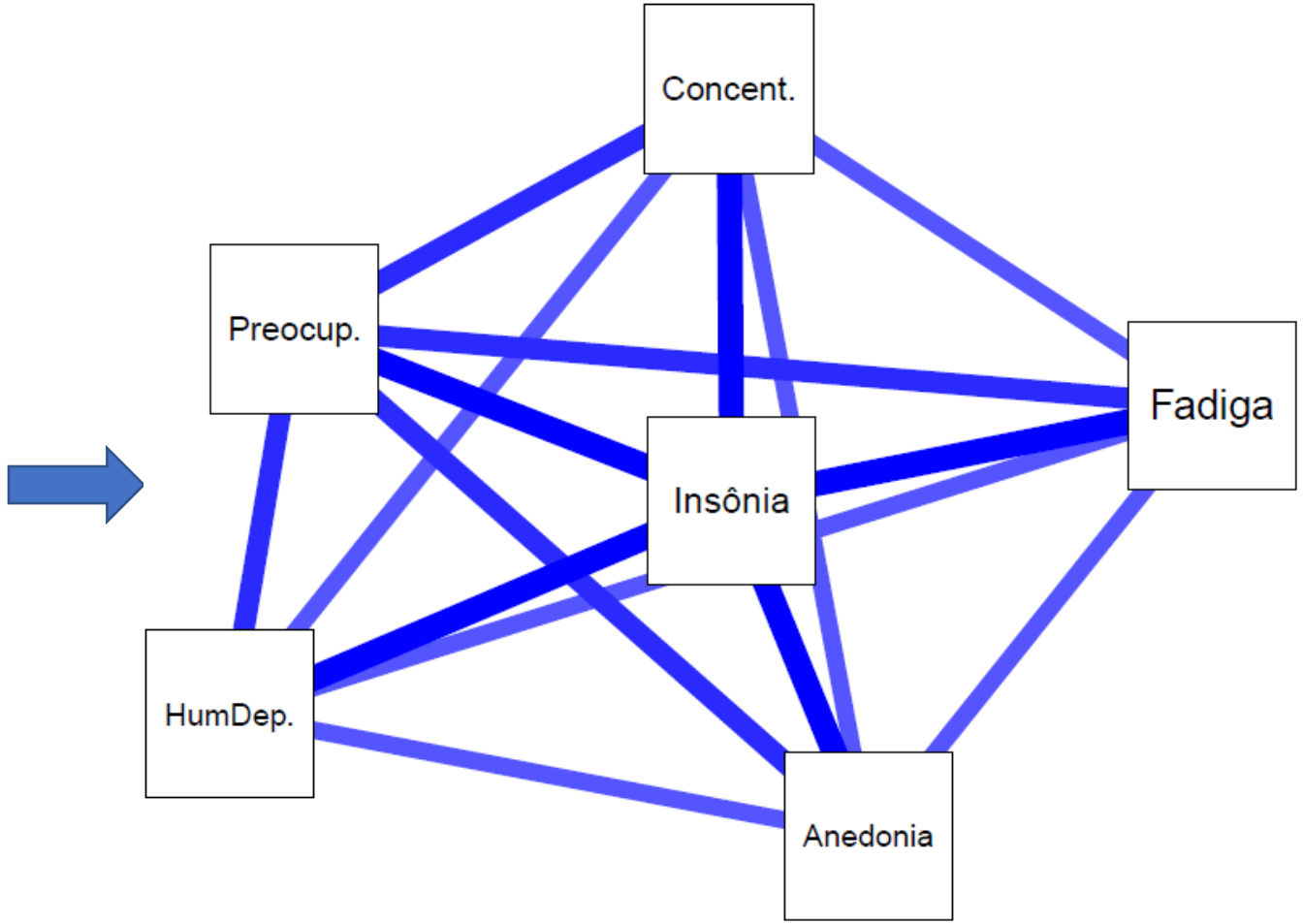
Department of Psychology, University of Amsterdam, Roetersstraat 15, 1018 WB Amsterdam, The Netherlands

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*).


Insônia
Fadiga
Concentração
Preocupações
Humor Dep
Anedonia

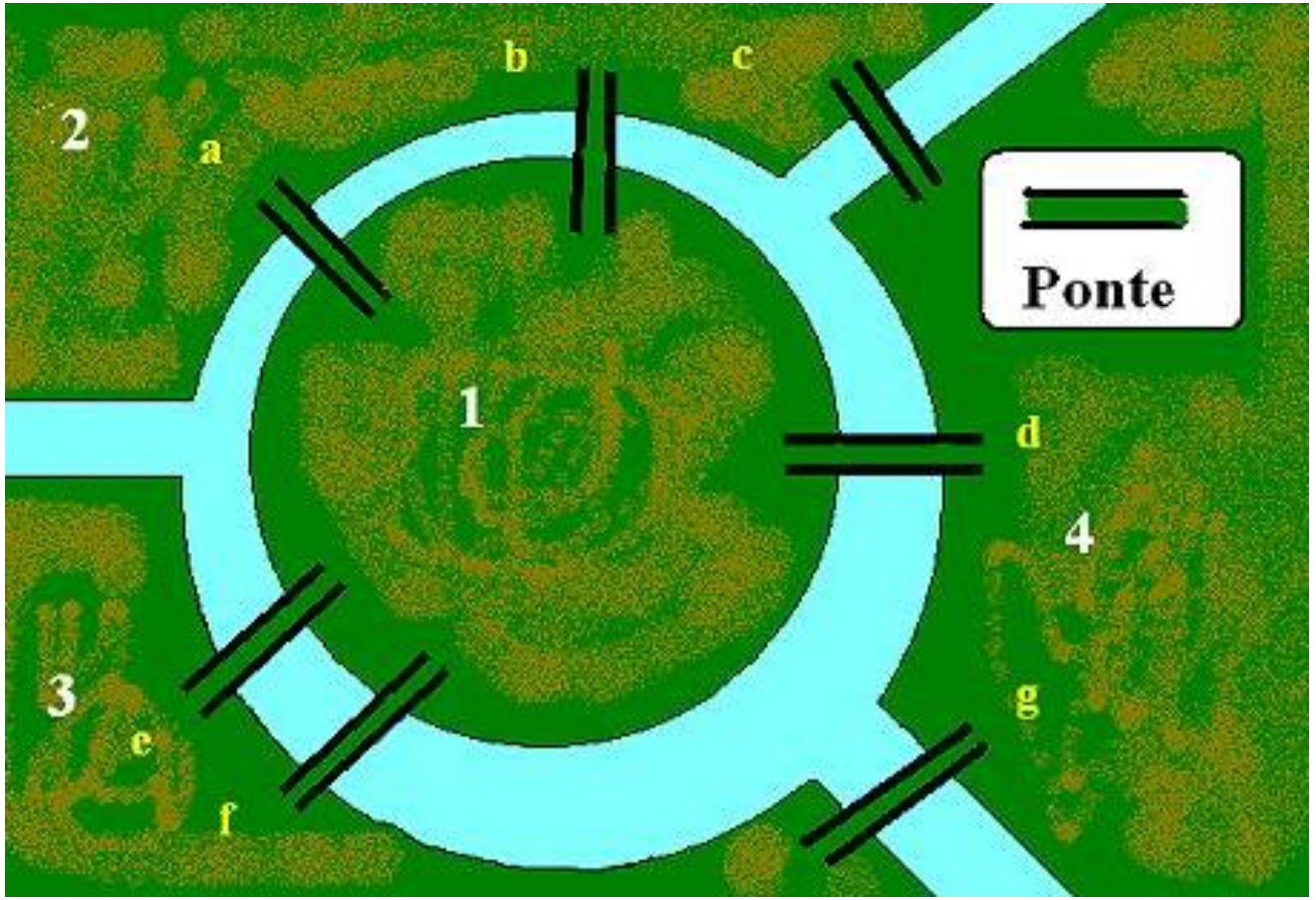
Depressão: **estrutura e dinâmica de um sistema**

	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

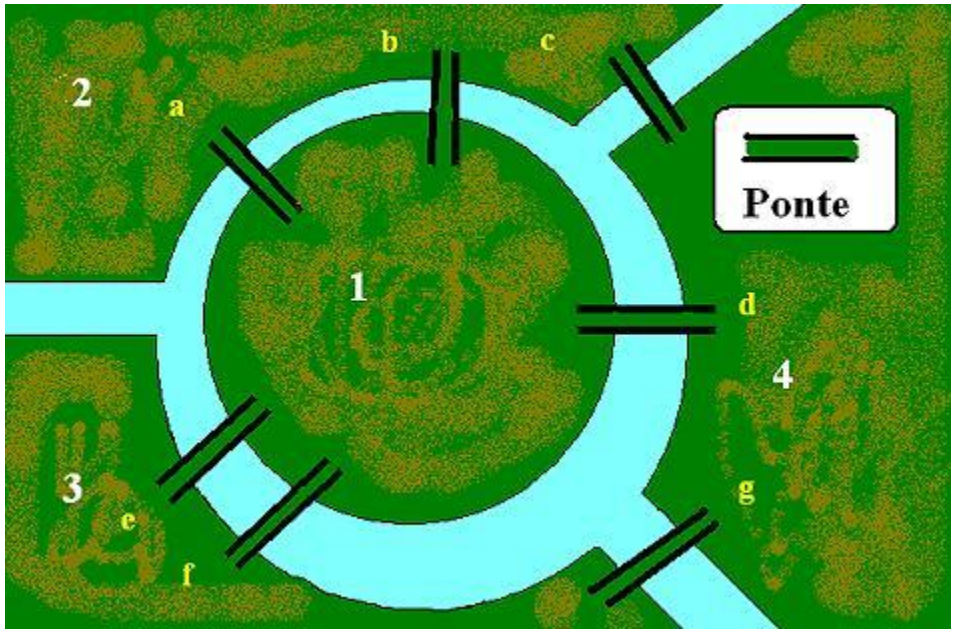
- O problema das pontes de Königsberg
- Discutia-se nas ruas da cidade a possibilidade de atravessar todas as pontes sem repetir nenhuma

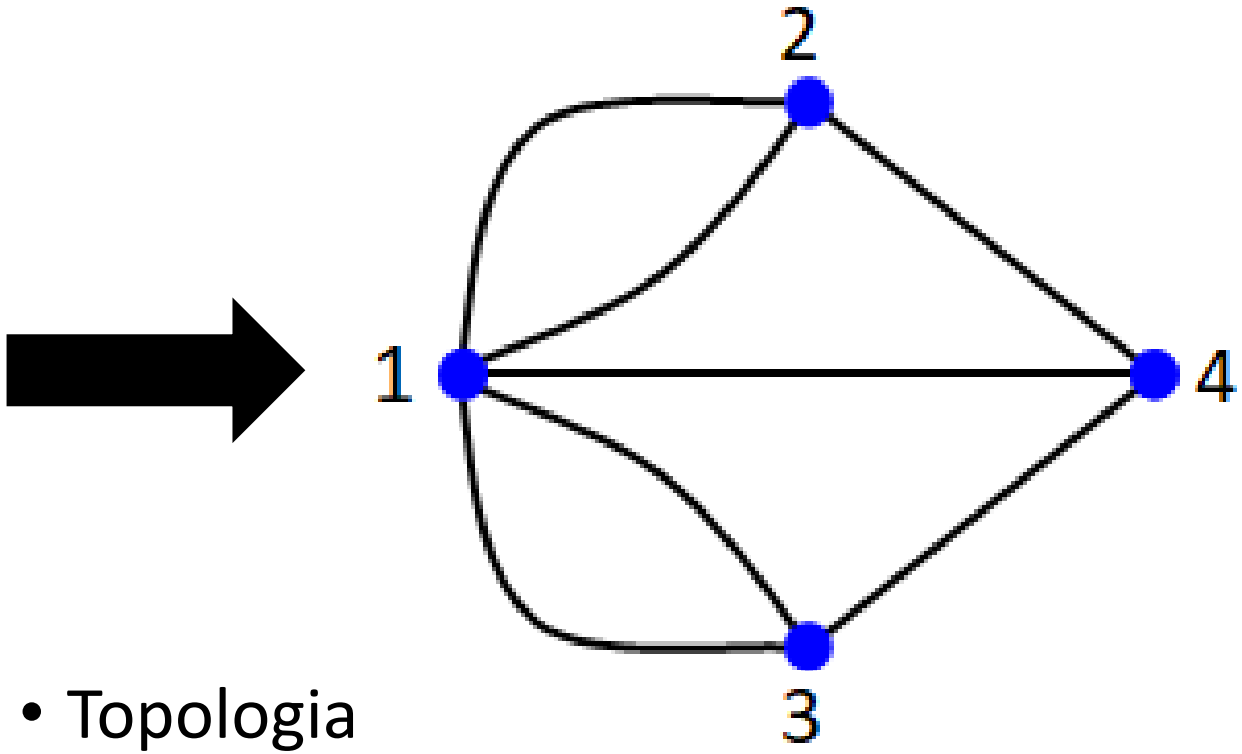


https://pt.wikipedia.org/wiki/Sete_pontes_de_K%C3%B6nigsberg

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

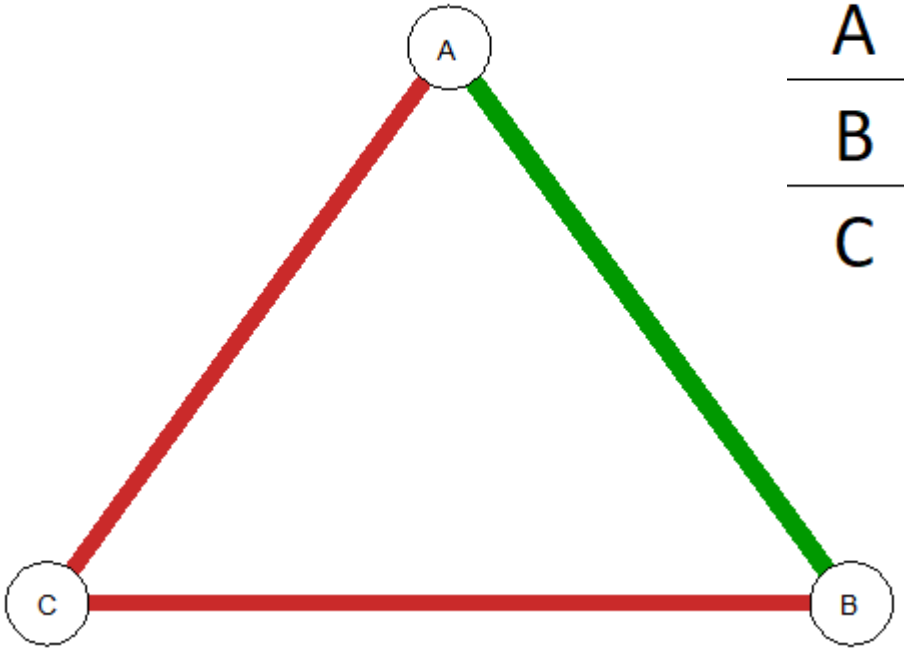
O que é uma rede?

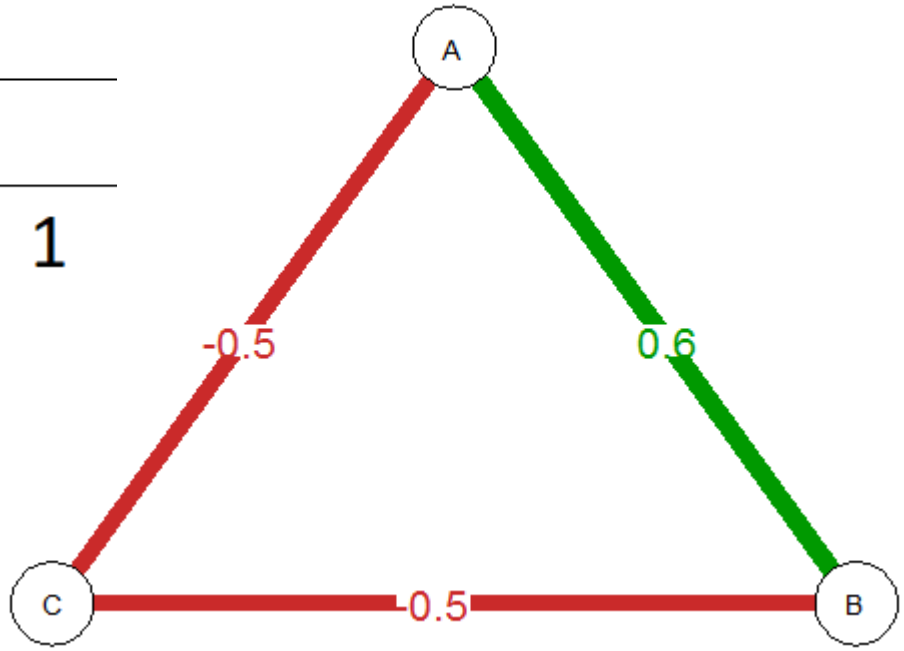
- Vértices (nodos) e arestas (linhas)
- Nodos representam variáveis
- As linhas representam a relação entre os nodos

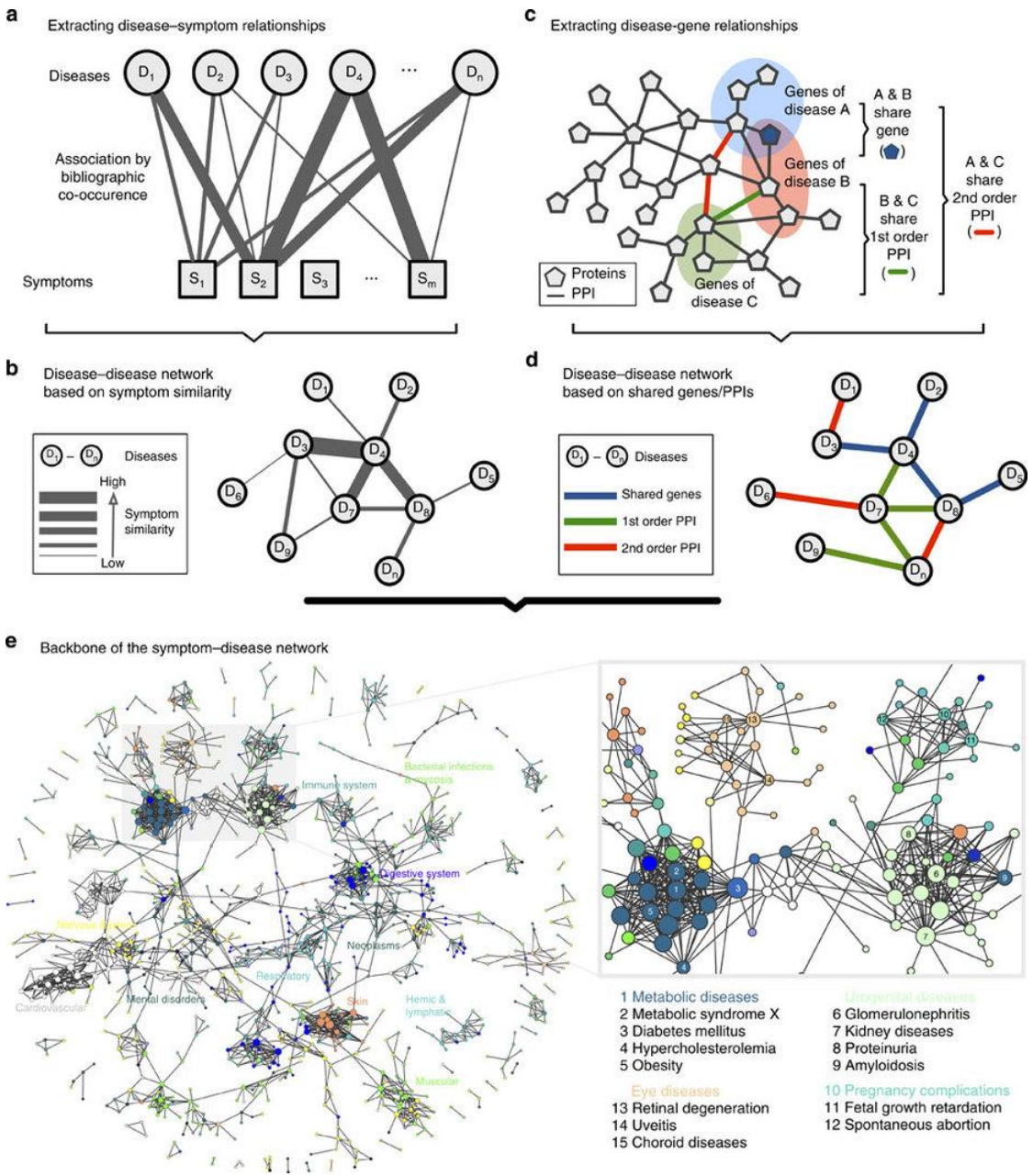
Medidas de associação entre variáveis

- 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







nature COMMUNICATIONS

Altmetric: 47 Views: 5,594 Citations: 33 More detail »

Article

Human symptoms–disease network

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

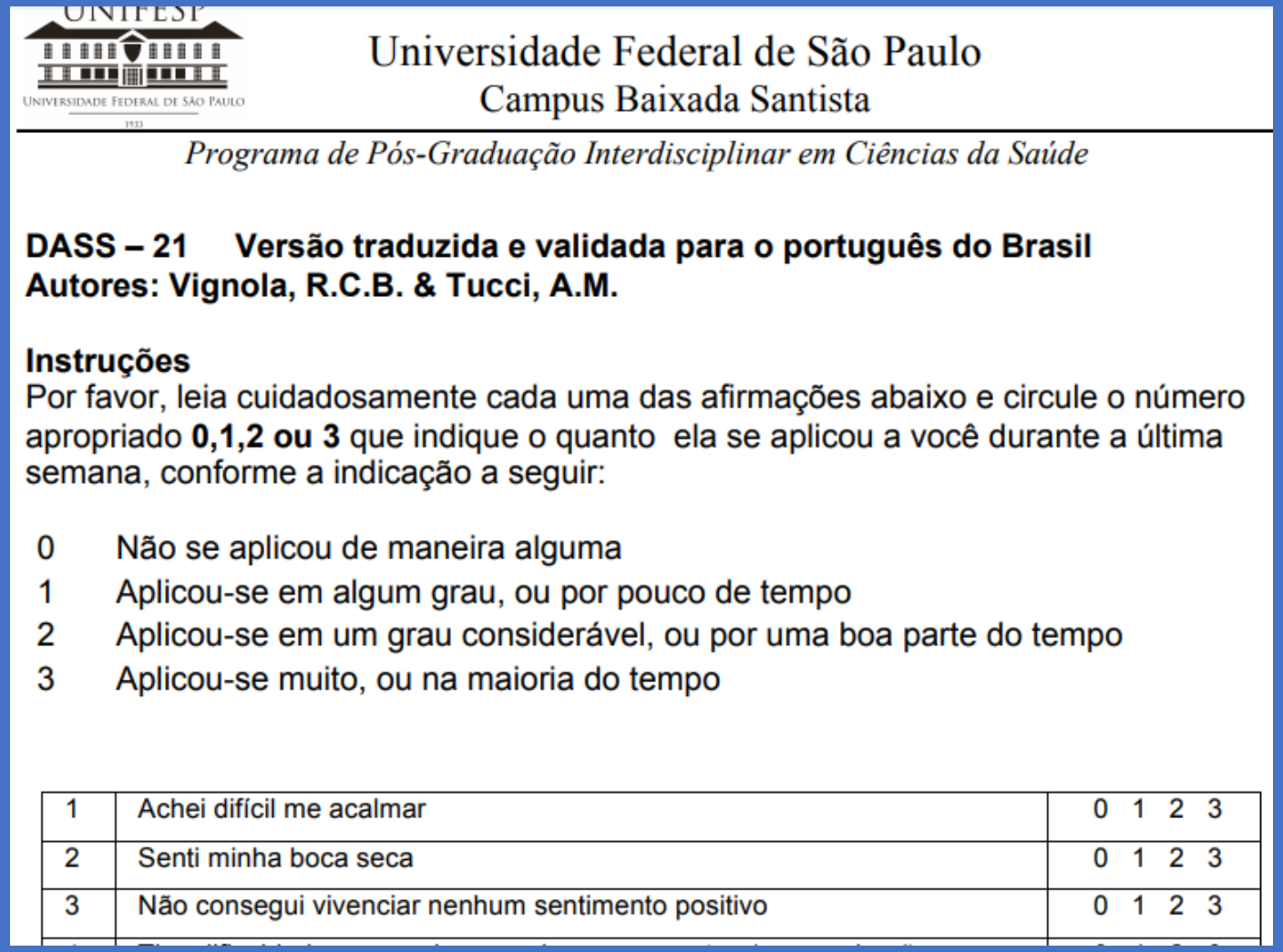
Nature Communications **5**,
Article number: 4212 (2014)
doi:10.1038/ncomms5212

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

Programa de Pós-Graduação Interdisciplinar em Ciências da Saúde

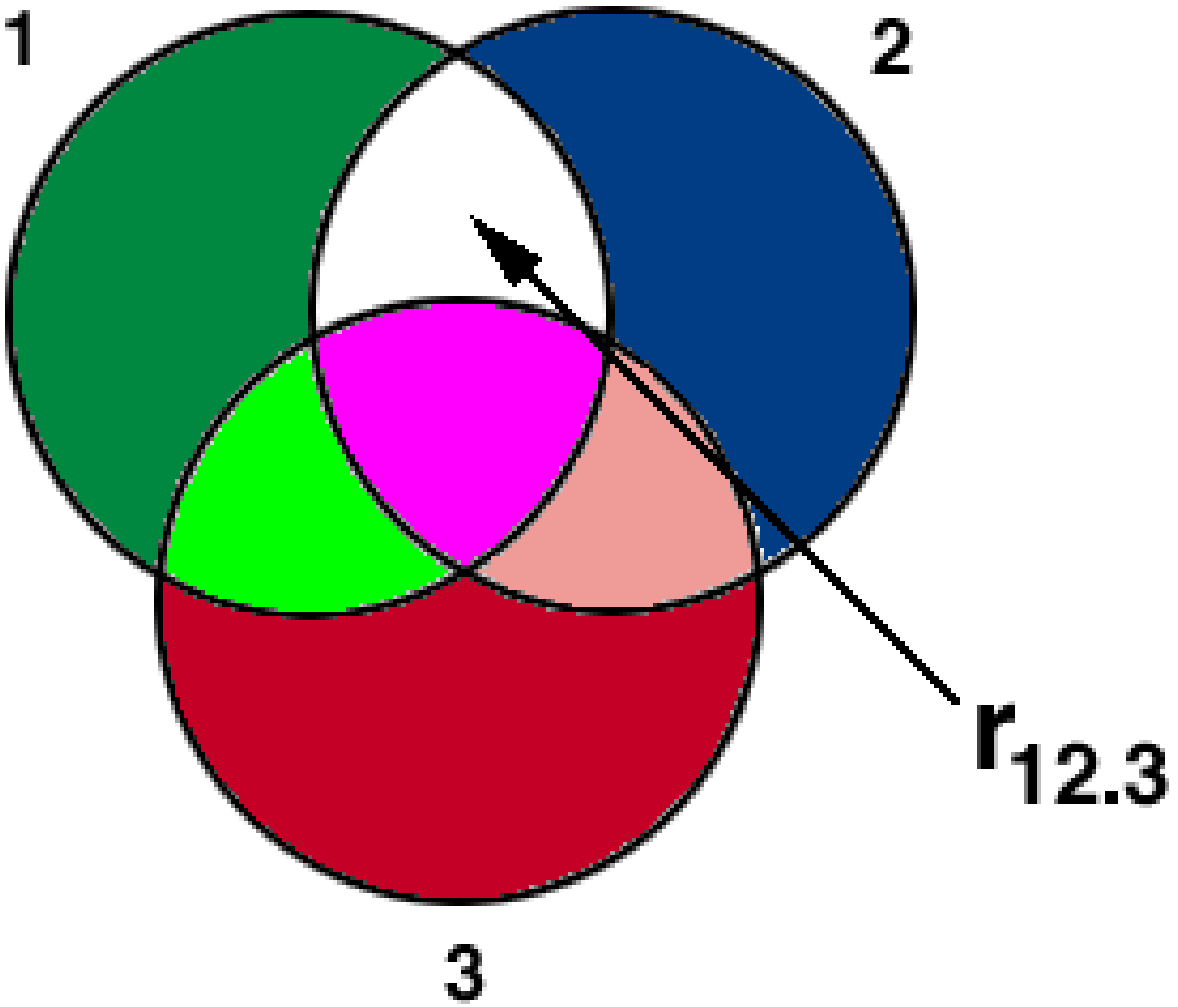
DASS – 21 Versão traduzida e validada para o português do Brasil
Autores: Vignola, R.C.B. & Tucci, A.M.

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

Correlação parcial



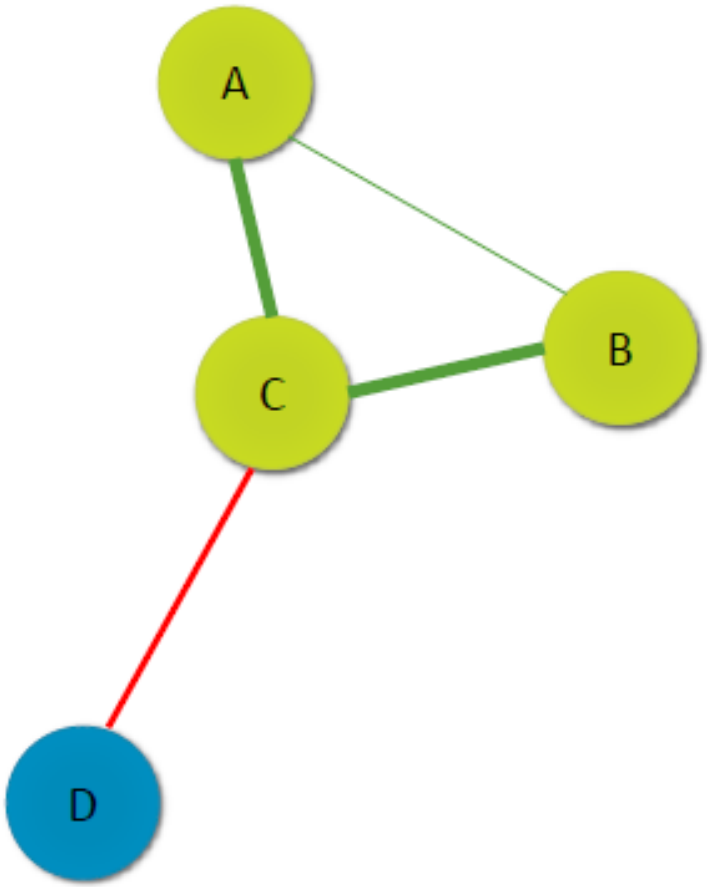
Regressão parcial (semiparcial)

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

- Problema da esparcialidade

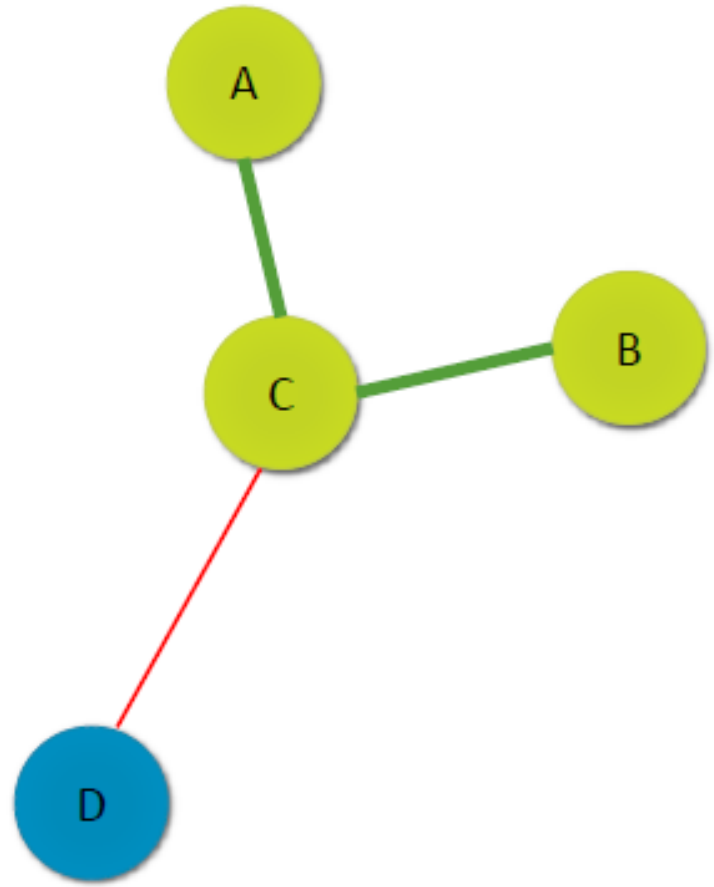
GeLasso estimation

- Graphical LASSO – (least absolute shrinkage and selection operator)
- Parâmetro de ajuste para o controle da esparcialidade (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 γ = 0, o método é o BIC.



Algoritmo GeLASSO

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



Friedman, Hastie & Tibshirani (2008)

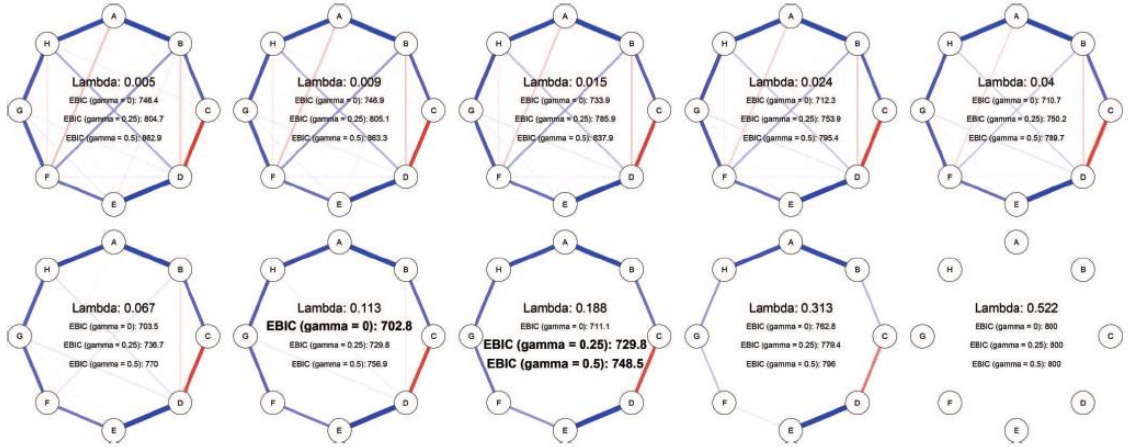


Figure 2. Ten different partial correlation networks estimated using lasso regularization. Setting the lasso tuning parameter λ that controls sparsity leads to networks ranging from densely connected to fully unconnected. Data were simulated under the network represented in Figure 1. The fit of every 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.

American Psychological Association

Psychological Methods

1082-989X/18/$12.00

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

A Tutorial on Regularized Partial Correlation Networks

Sacha Epskamp and Eiko I. Fried
University of Amsterdam

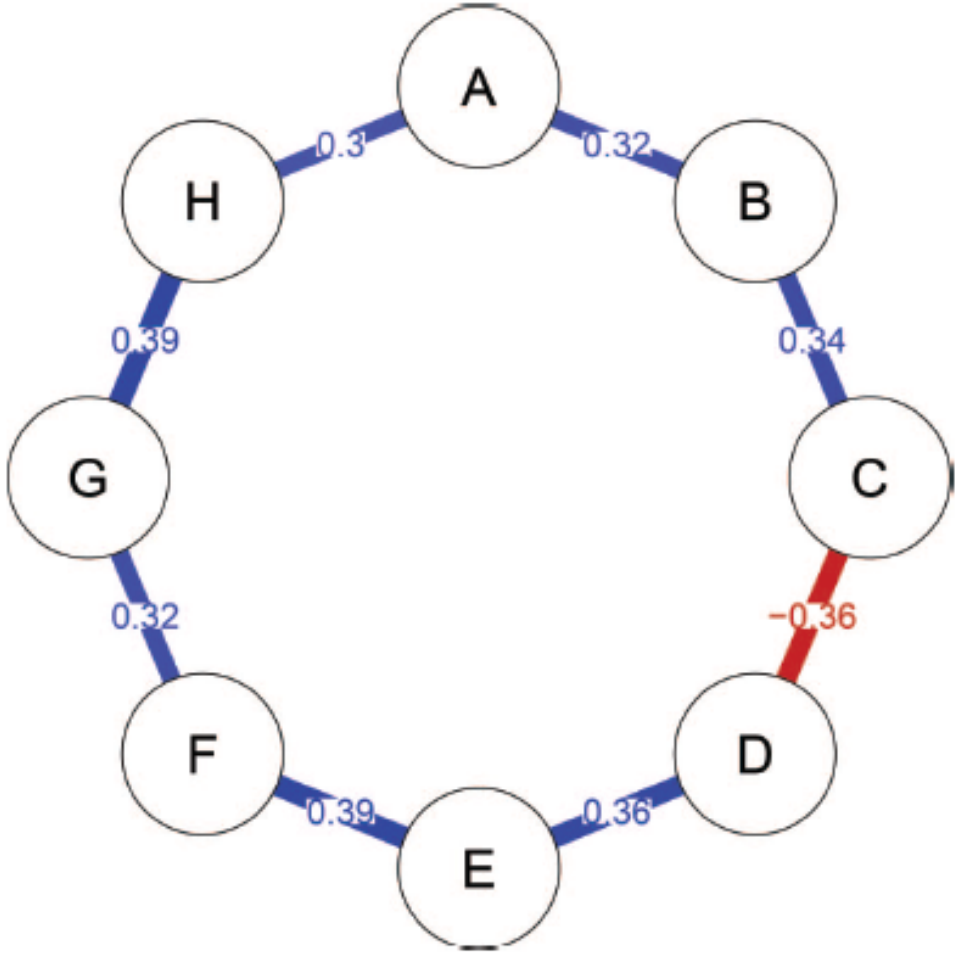
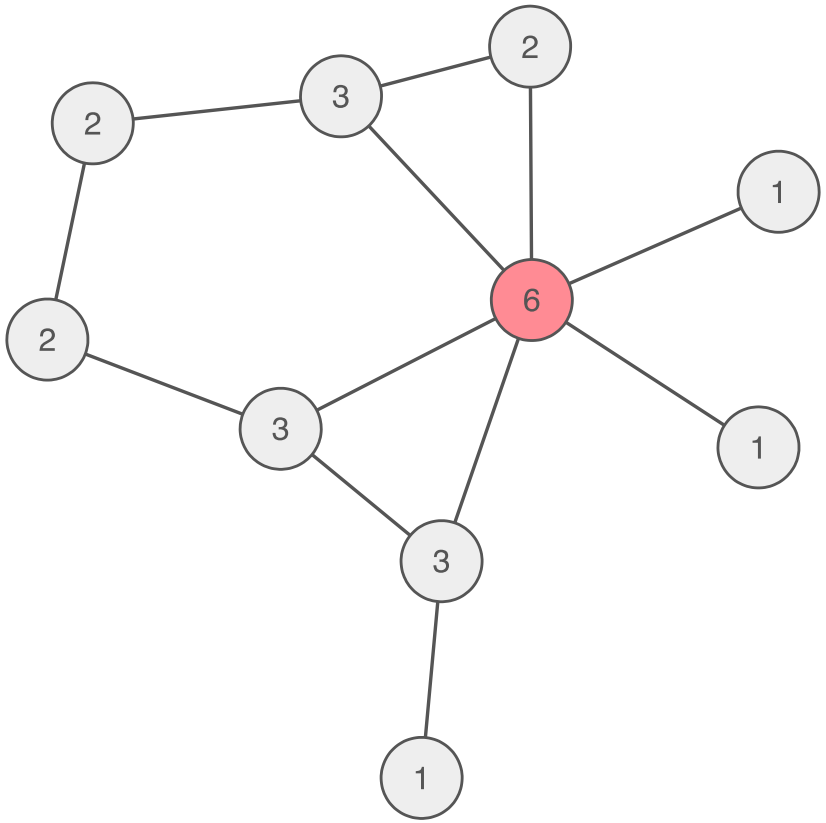


Figure 1. True network structure used in simulation example. The network represents a *partial correlation network*: nodes represent observed variables and edges represent partial correlations between two variables after conditioning on all other variables. The simulated structure is a *chain graph* 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.

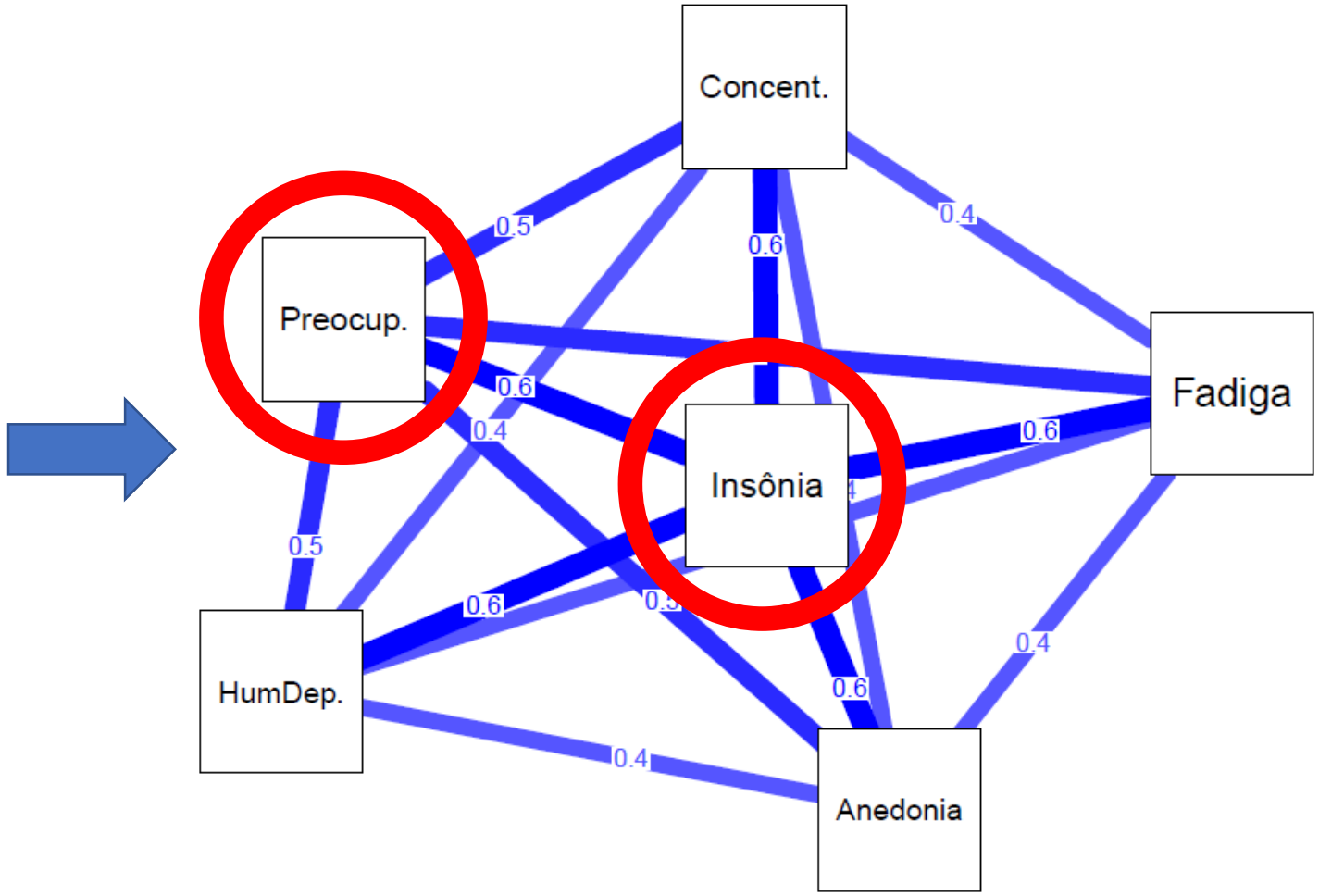
Centralidade



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

Published in final edited form as:

J Abnorm Psychol. 2016 August ; 125(6): 747–757. doi:10.1037/abn0000181.

Identifying Highly Influential Nodes in the Complicated Grief Network

Donald J. Robinaugh[1,2], **Alexander J. Millner**[3], and **Richard J. McNally**[3]

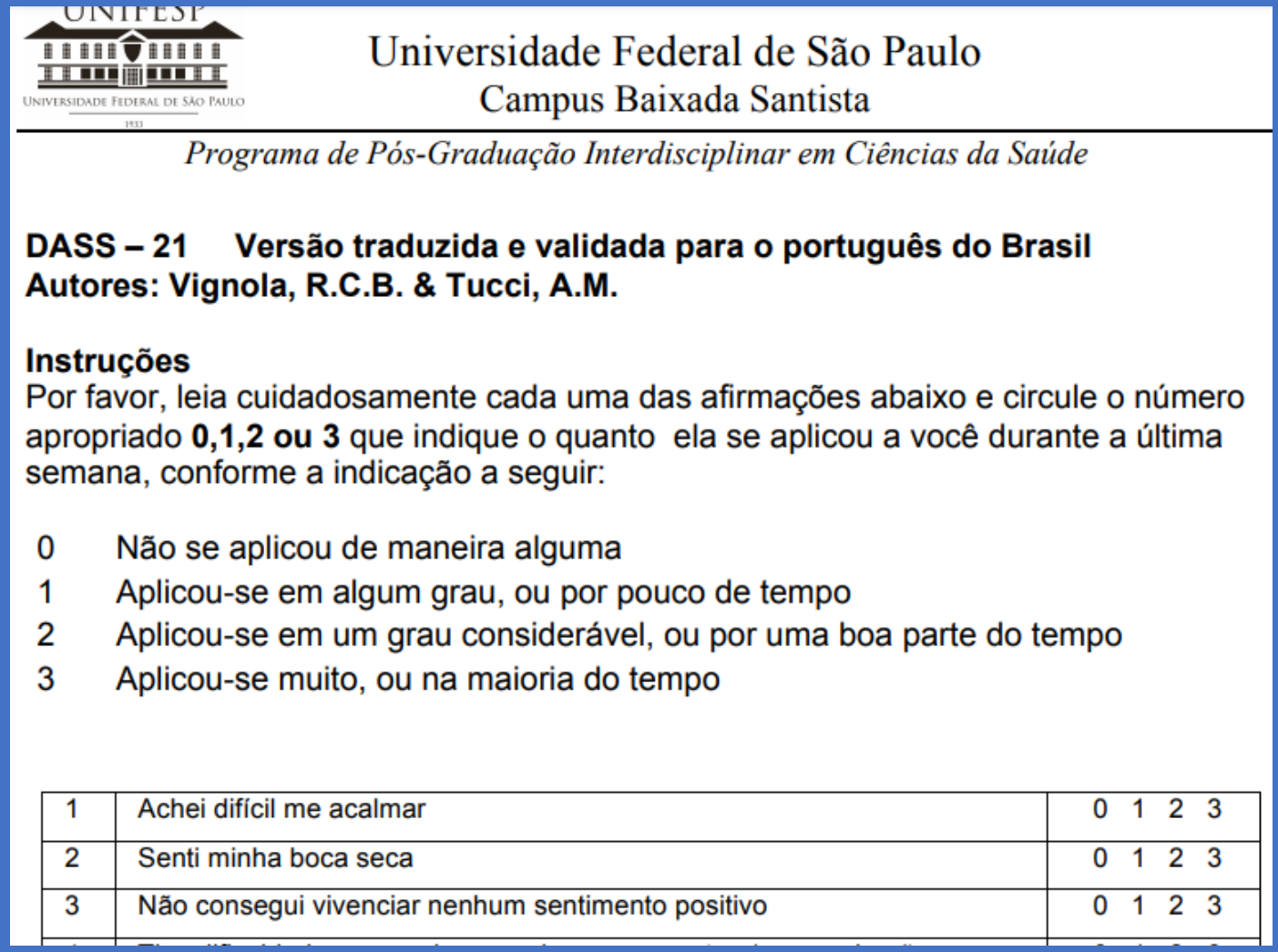
[1]Massachusetts General Hospital, Department of Psychiatry

[2]Harvard Medical School

[3]Department of Psychology, Harvard University

Exemplos com todos os itens da DASS21

- RStudio



Universidade Federal de São Paulo
Campus Baixada Santista

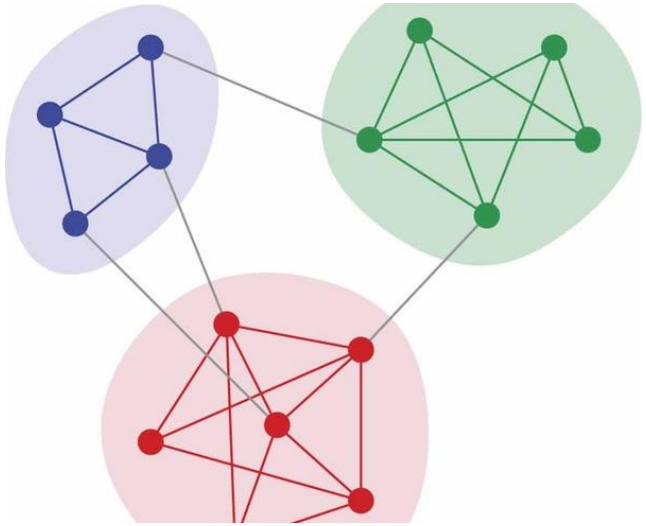
Programa de Pós-Graduação Interdisciplinar em Ciências da Saúde

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



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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

Received: 31 March 2016
Accepted: 07 July 2016
Published online: 01 August 2016

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 dentre 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)

PLOS ONE

RESEARCH ARTICLE

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

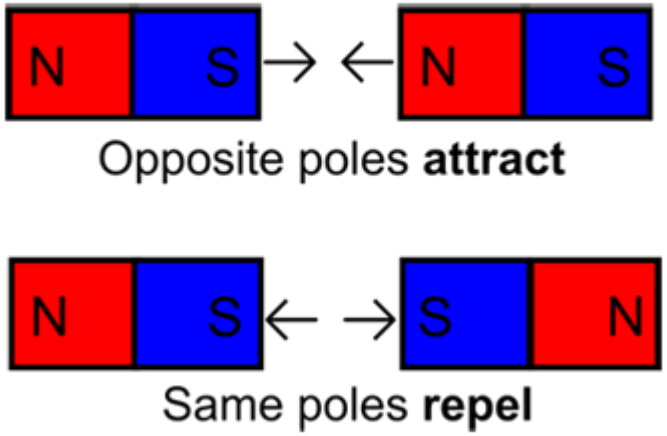
Hudson F. Golino[1,2]*, Sacha Epskamp[3]

Exemplo com dados dicotômicos/binários

- Ising Model e TRI multidimensional

Ising model

- Estudo do ferromagnetismo



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SUBJECT AREAS:
PSYCHOLOGY
SIGNS AND SYMPTOMS

A new method for constructing networks from binary data

Claudia D. van Borkulo[1,2], Denny Borsboom[2], Sacha Epskamp[2], Tessa F. Blanken[2], Lynn Boschloo[1], Robert A. Schoevers[1] & Lourens J. Waldorp[2]

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

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

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Three representations of the Ising model

Joost Kruis[1] & Gunter Maris[1,2]

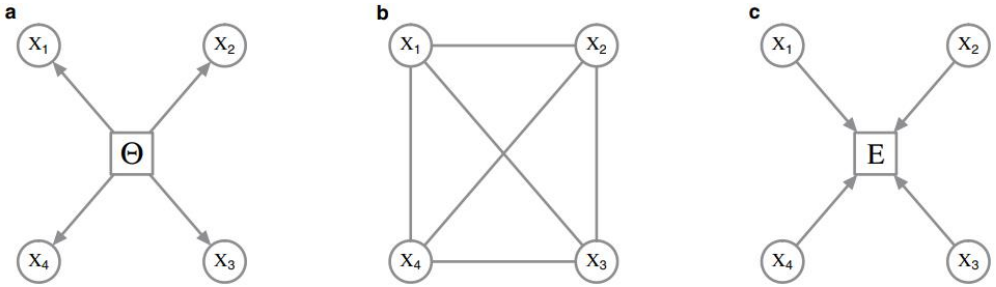


Figure 1. Three frameworks for explaining observed associations in the parametrisation of their prototypical statistical models. (**a**) The Rasch model from the common cause framework as a DAG. (**b**) The Curie-Weiss model from the reciprocal affect framework as an undirected graph. (**c**) The collider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

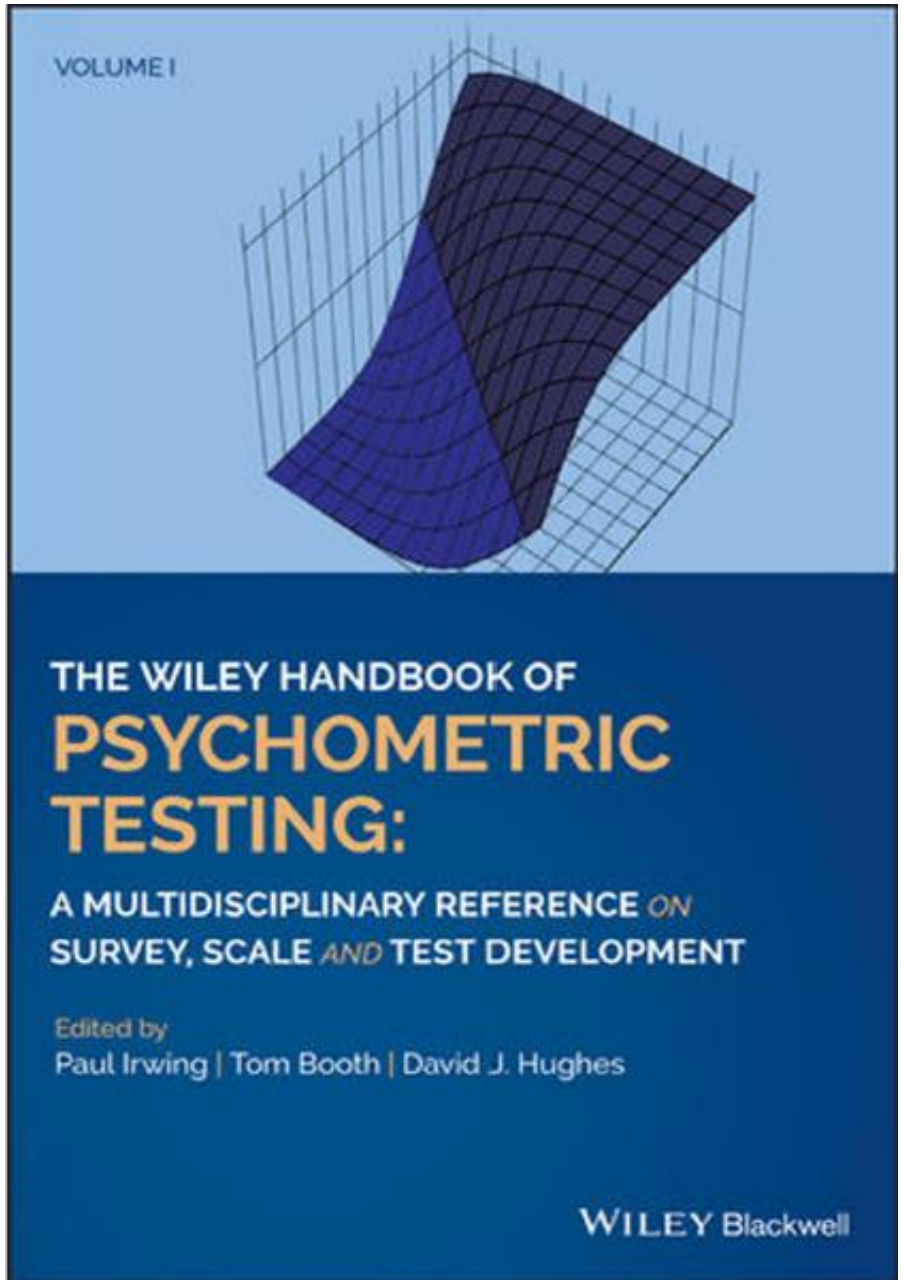
In IRT, the responses on a set of binary variables $\boldsymbol{X}$ are assumed to be determined by a set of M ($M \leq P$) latent variables $\boldsymbol{\Theta}^\top = [\Theta_1\, \Theta_2 \ldots \Theta_M]$. These latent variables are often termed *abilities*, which betrays the roots of the model in 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 $\boldsymbol{\theta}$. For instance, in the (Rasch, 1960) model, also called the one-parameter logistic model (1PL), only one latent trait is assumed ($M = 1$ and $\boldsymbol{\Theta} = \Theta$) and the conditional probability of a response given the latent trait takes the form of a simple logistic function:

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

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
- ?

GRUPO DE PESQUISA

AVALIAÇÃO EM BEM-ESTAR E SAÚDE MENTAL

MELHOR PÓS-GRADUAÇÃO DO BRASIL
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NETWORK PSYCHOMETRICS
uma introdução

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