

# Análise de rede: uma introdução e aplicações na psicologia

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Humano

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Avaliação em Psicologia Positiva e Criatividade (ANPEPP)

# Resumo

- O curso tem por objetivo fazer uma breve introdução à análise de rede. Serão abordados seus fundamentos e aplicações na psicologia, em especial na psicométrica. Apesar de seu uso recente na psicologia a análise de rede (ou de grafos) é uma técnica muito utilizada em outras áreas do conhecimento como, por exemplo, ecologia, genética, medicina (oncologia, epidemiologia) e tecnologia de informação. A análise de rede combina a teoria de grafos com algoritmos robustos para estimação da estrutura e dinâmica de sistemas complexos. Alguns exemplos de aplicações na psicologia são: modelos estruturais indutivos, estudo de agrupamentos ou comunidades de variáveis, modelos de mediação, estudo de comorbidade e comparações entre grupos.

# Roteiro

- Introdução e exemplos
- Representação de dados psicométricos em rede
- Redes gaussianas
- Estatísticas de centralidade
- Redes de dados dicotômicos
- Redes de dados misturados (mixed)
- Análise de comunidades
- Comparação de redes
- Estabilidade da rede
- Predição de variáveis
- Modelos de rede de variáveis latentes

# Materiais

- Software estatístico R
- R Studio – interface amigável e interativa do R
- Lista de pacotes (email)
- <https://github.com/wagnerLM/networkIBAP>
- Bancos e o script (lista de comandos) do curso

# Introdução e exemplos

- Paradigma de rede
- Paradoxo da era da informação (proporcionalmente, cada vez sabe-se menos, apesar de se ter mais informação disponível)
- Complexidade enquanto prática (não só discurso)

“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.”

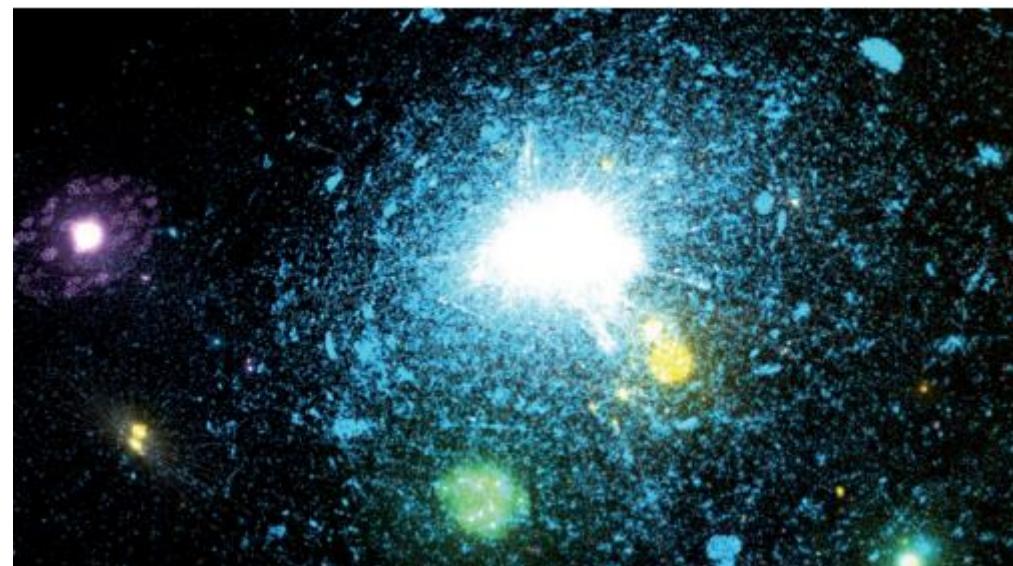
NATURE PHYSICS | COMMENTARY

## The network takeover

Albert-László Barabási

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

Published online 22 December 2011



# O que é uma rede?

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



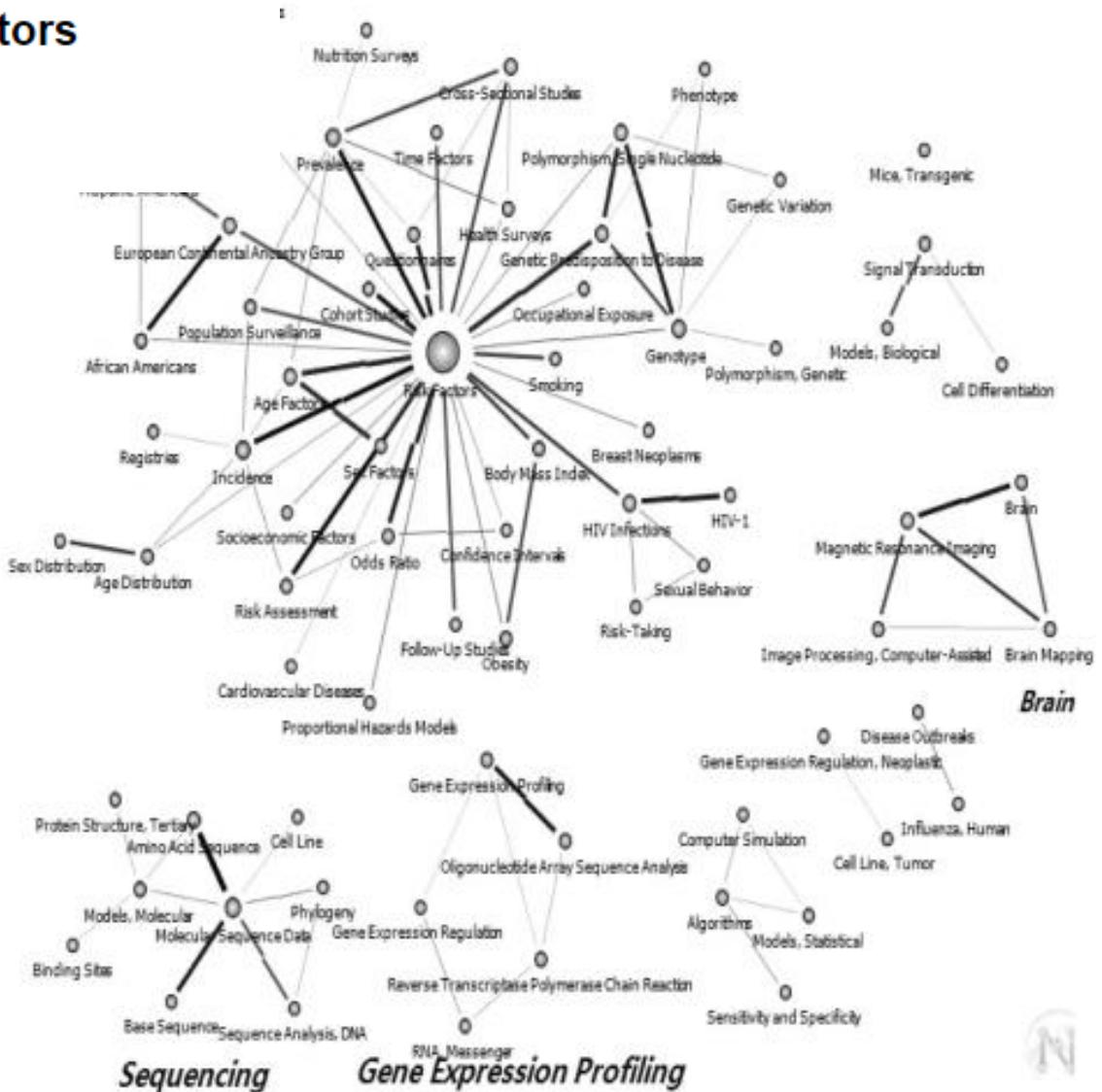
# Social network analysis

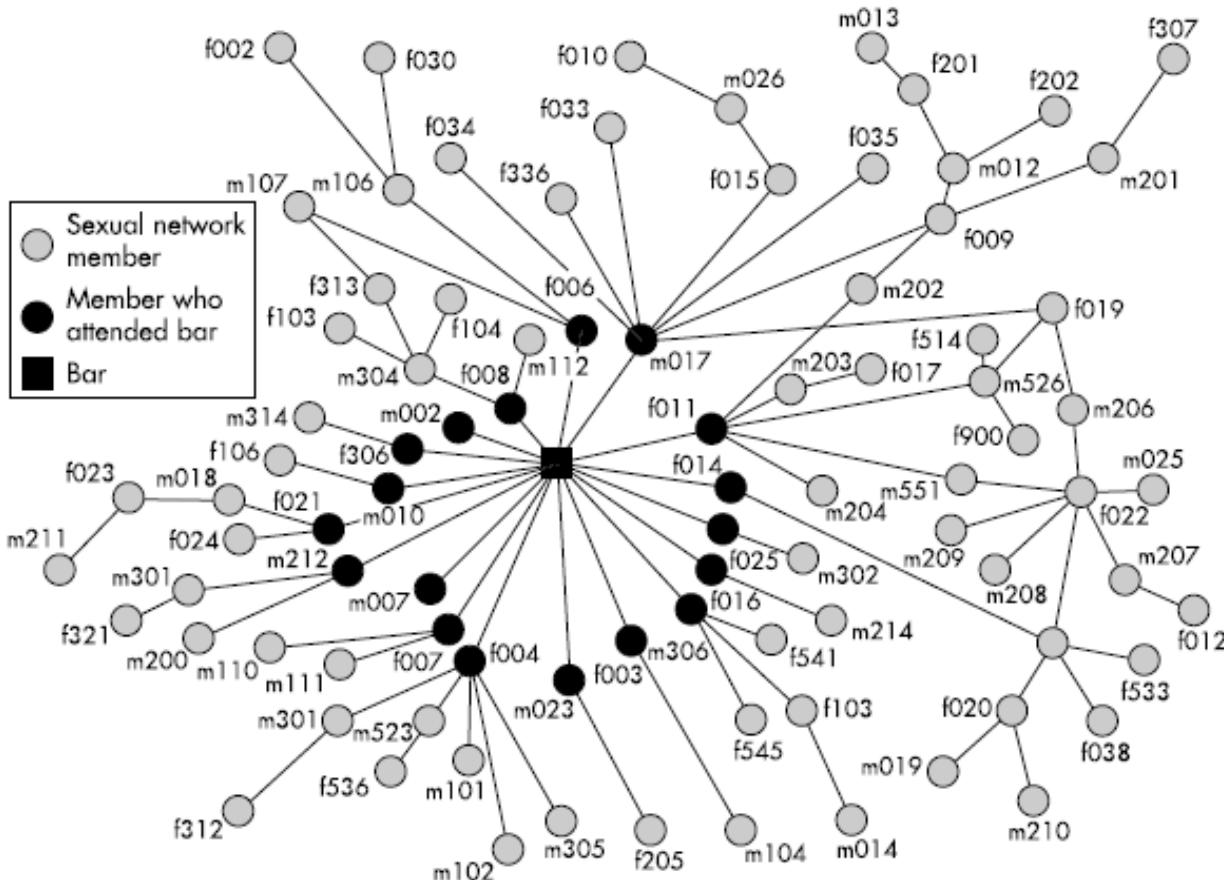
- Medicina
- Ecología

## Application of Social Network Analysis to Health Care Sectors

Hae Lan Jang, PhD,<sup>1</sup> Young Sung Lee, MD, PhD,<sup>1</sup> and Ji-Young An, PhD<sup>✉,2</sup>

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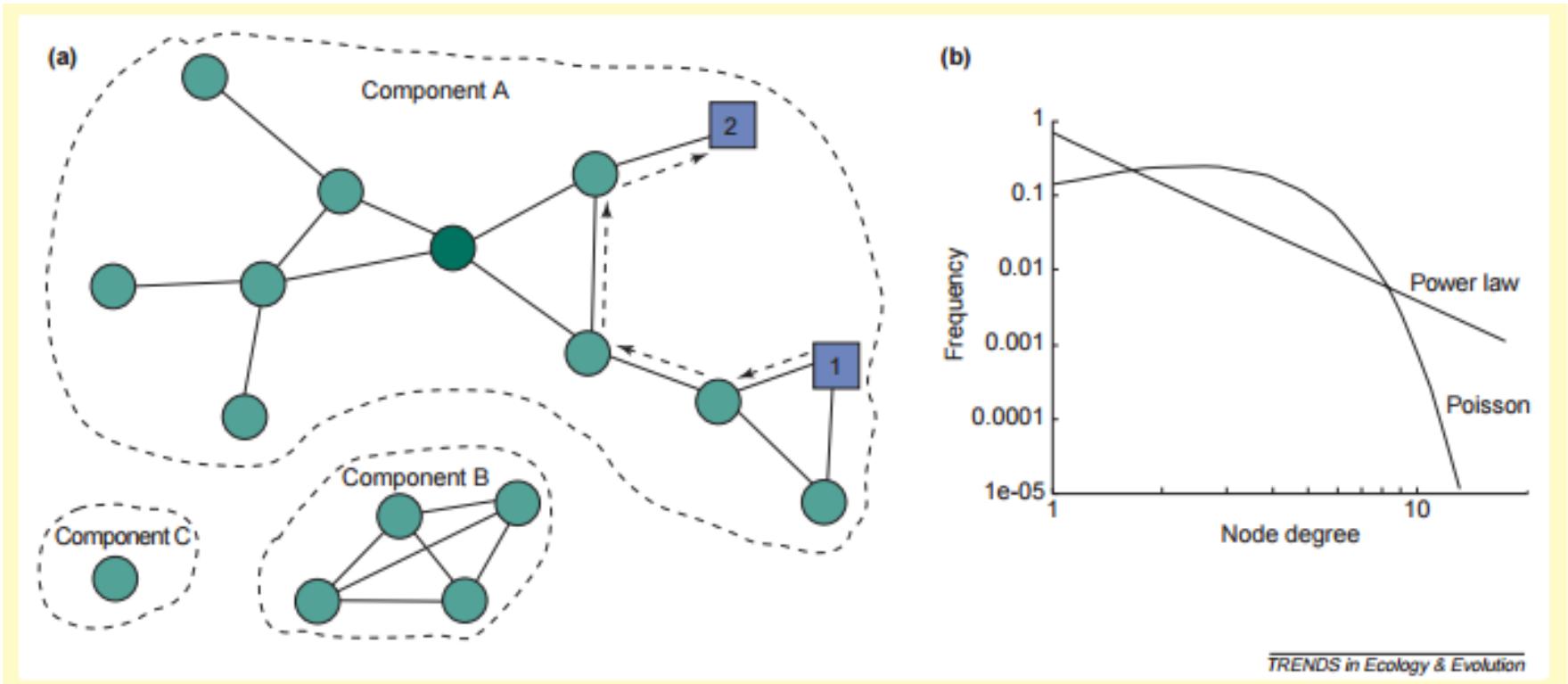


**Figure 2** Network members ( $n=89$ ) viewed by their connection through a bar associated with gonorrhoea acquisition. A prefix to the unique identifier of "m" designates a male and "f" indicates a female sexual partner. Bar patrons possessed significantly higher information centrality measures compared to non-patrons (table 3).

## ORIGINAL ARTICLE

# Sexual network analysis of a gonorrhoea outbreak

P De, A E Singh, T Wong, W Yacoub, A M Jolly



*TRENDS in Ecology & Evolution*



Review

*TRENDS in Ecology and Evolution* Vol.20 No.6 June 2005

Full text provided by www.sciencedirect.com



# Network thinking in ecology and evolution

Stephen R. Proulx<sup>1</sup>, Daniel E.L. Promislow<sup>2</sup> and Patrick C. Phillips<sup>1</sup>

<sup>1</sup>Center for Ecology and Evolutionary Biology, 5289 University of Oregon, Eugene, OR 97403-5289, USA

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NATURE NEUROSCIENCE | REVIEW

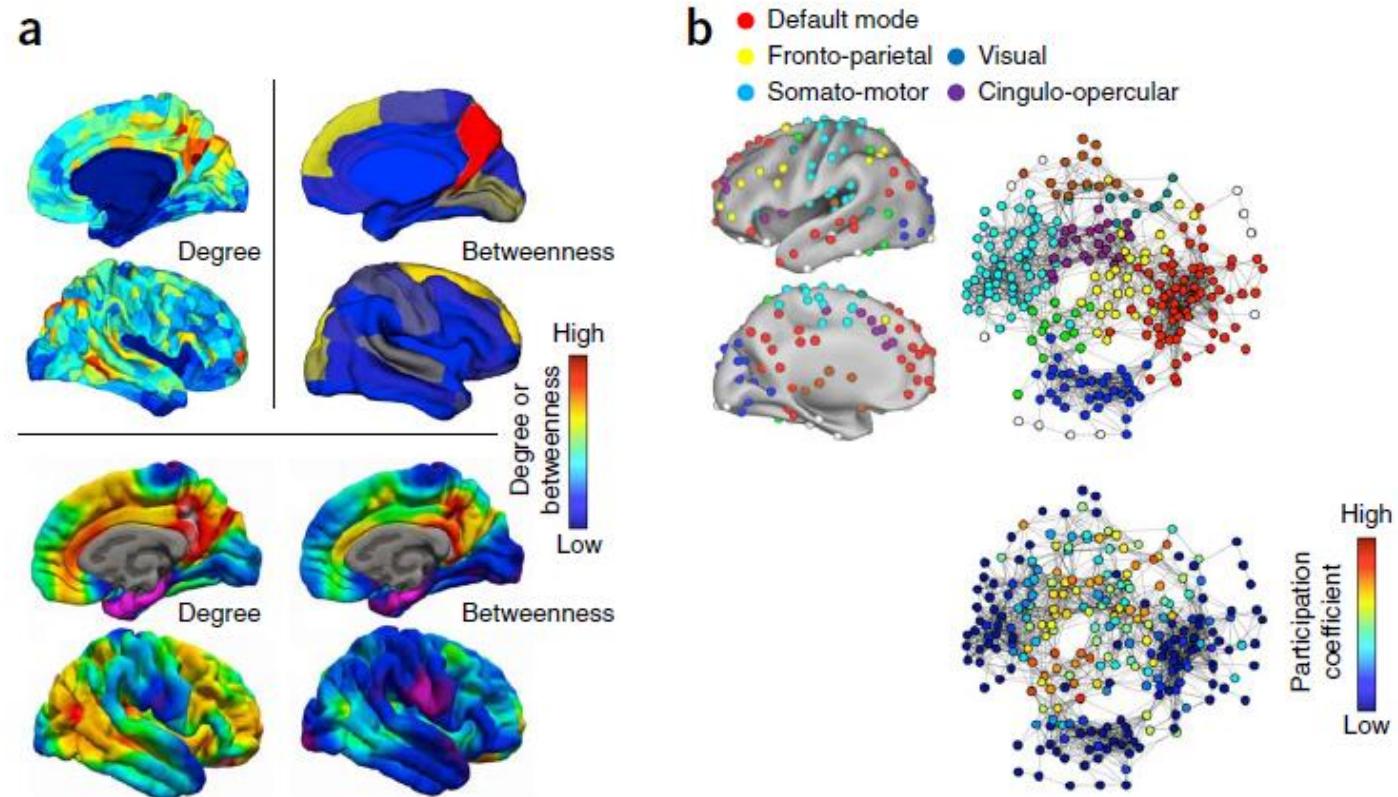


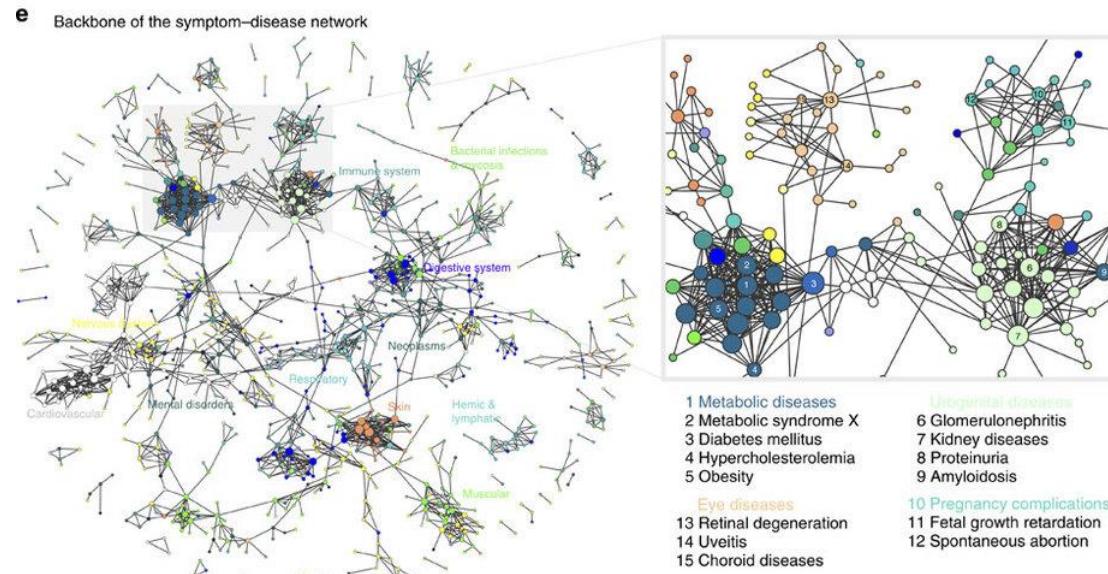
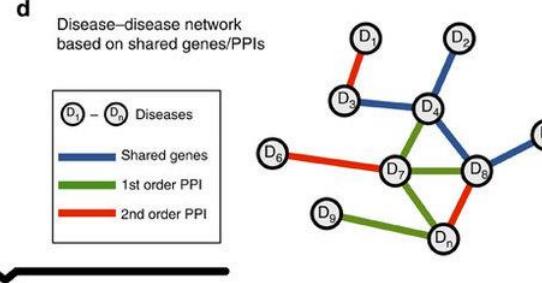
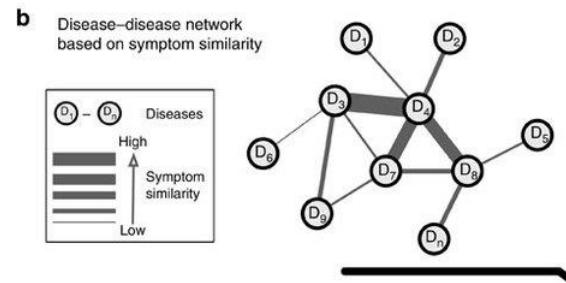
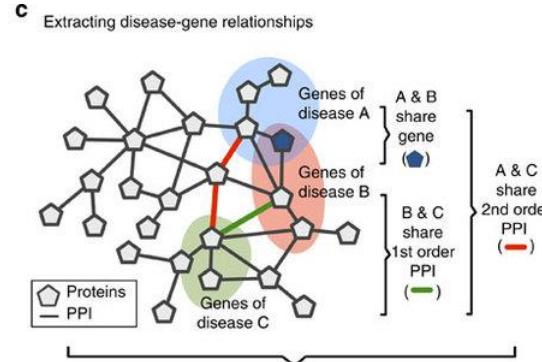
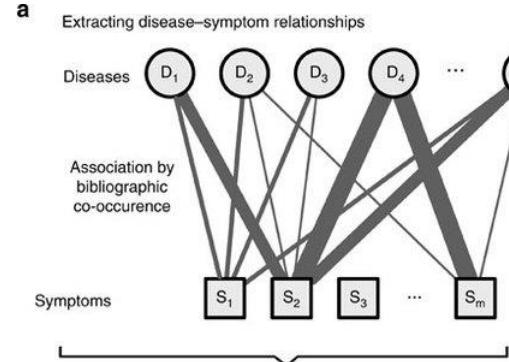
## Contributions and challenges for network models in cognitive neuroscience

**Olaf Sporns**

Nature Neuroscience 17, 652–660 (2014) | doi:10.1038/nn.3690

Received 06 October 2013 | Accepted 03 March 2014 | Published online 30 March 2014





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

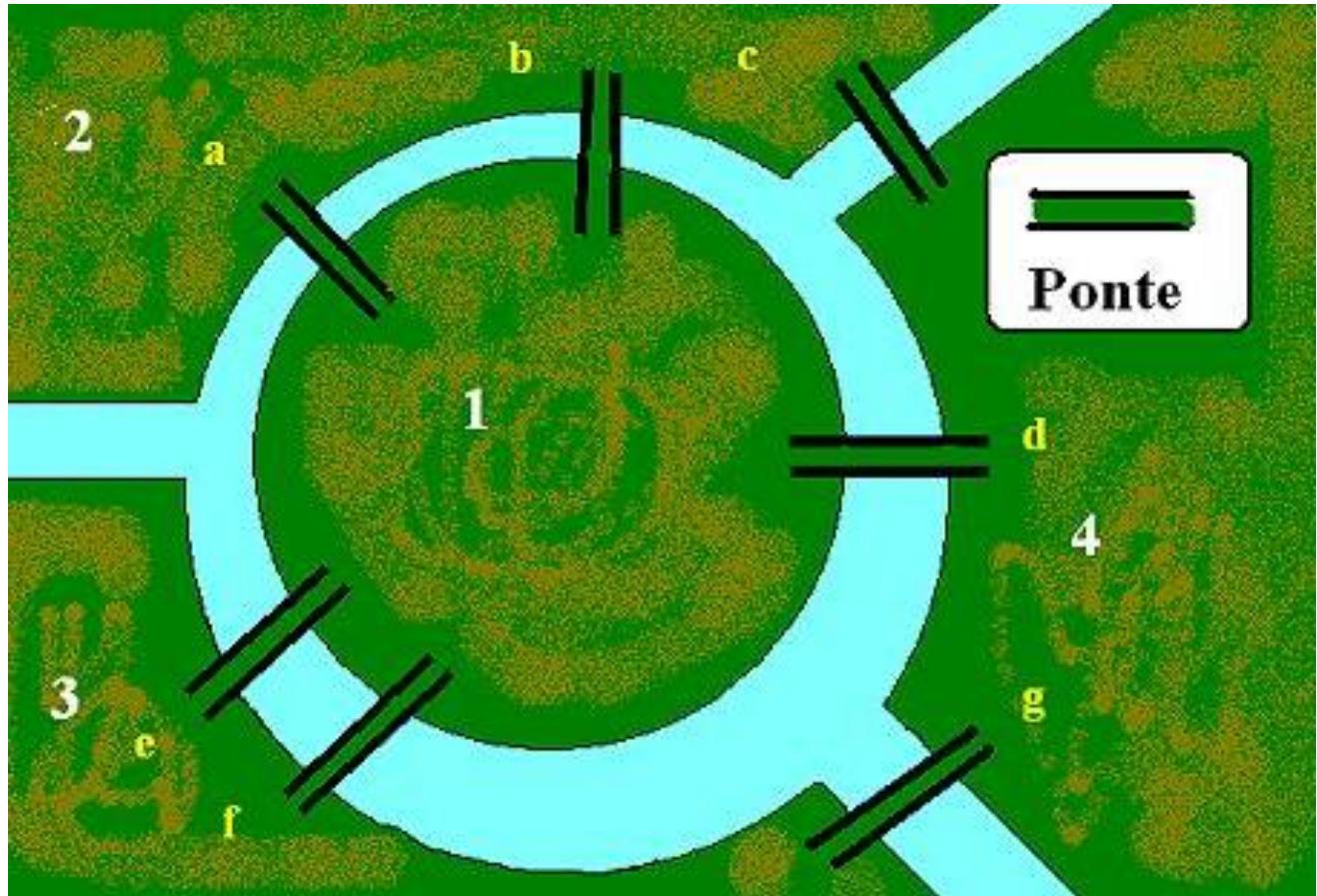
Accepted: 27 May 2014

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

# Teoria dos grafos

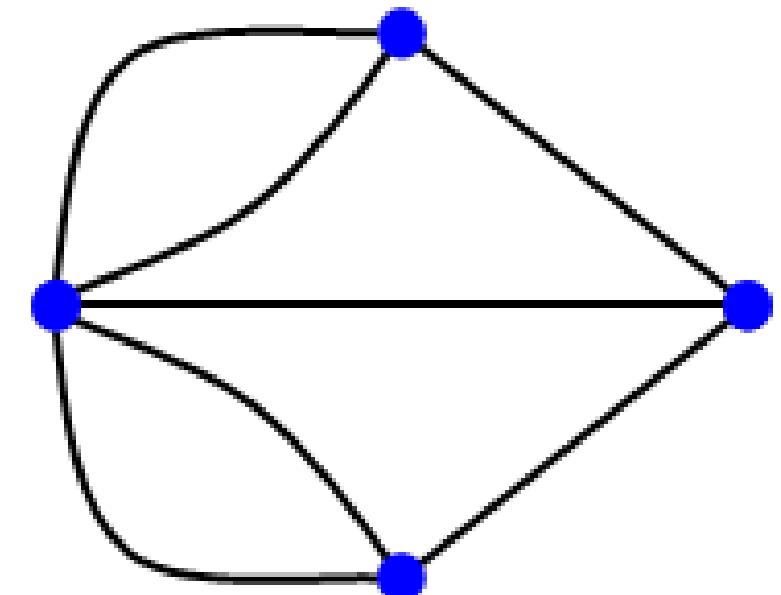
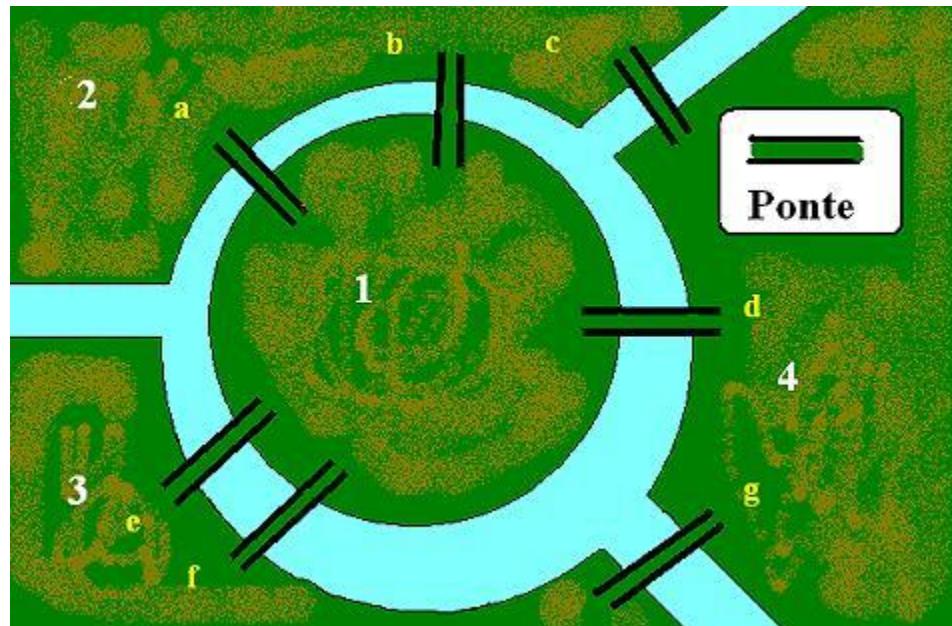
- O problema das pontes de Königsberg
- Discutia-se nas ruas da cidade a possibilidade de atravessar todas as pontes sem repetir nenhuma



[https://pt.wikipedia.org/wiki/Sete\\_pontes\\_de\\_K%C3%B6nigsberg](https://pt.wikipedia.org/wiki/Sete_pontes_de_K%C3%B6nigsberg)

# Teoria dos grafos

- Havia-se tornado uma lenda popular a possibilidade da façanha quando Leonhard Euler , em 1736, provou que não existia caminho que possibilitasse tais restrições.

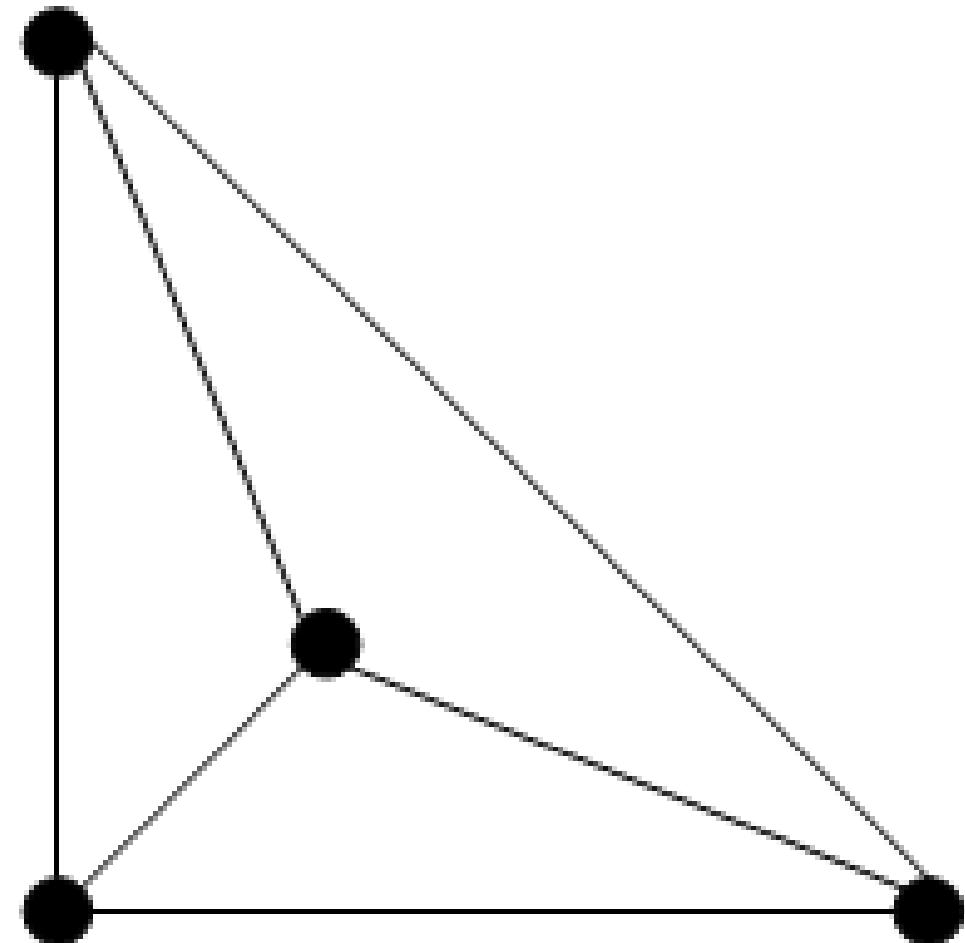


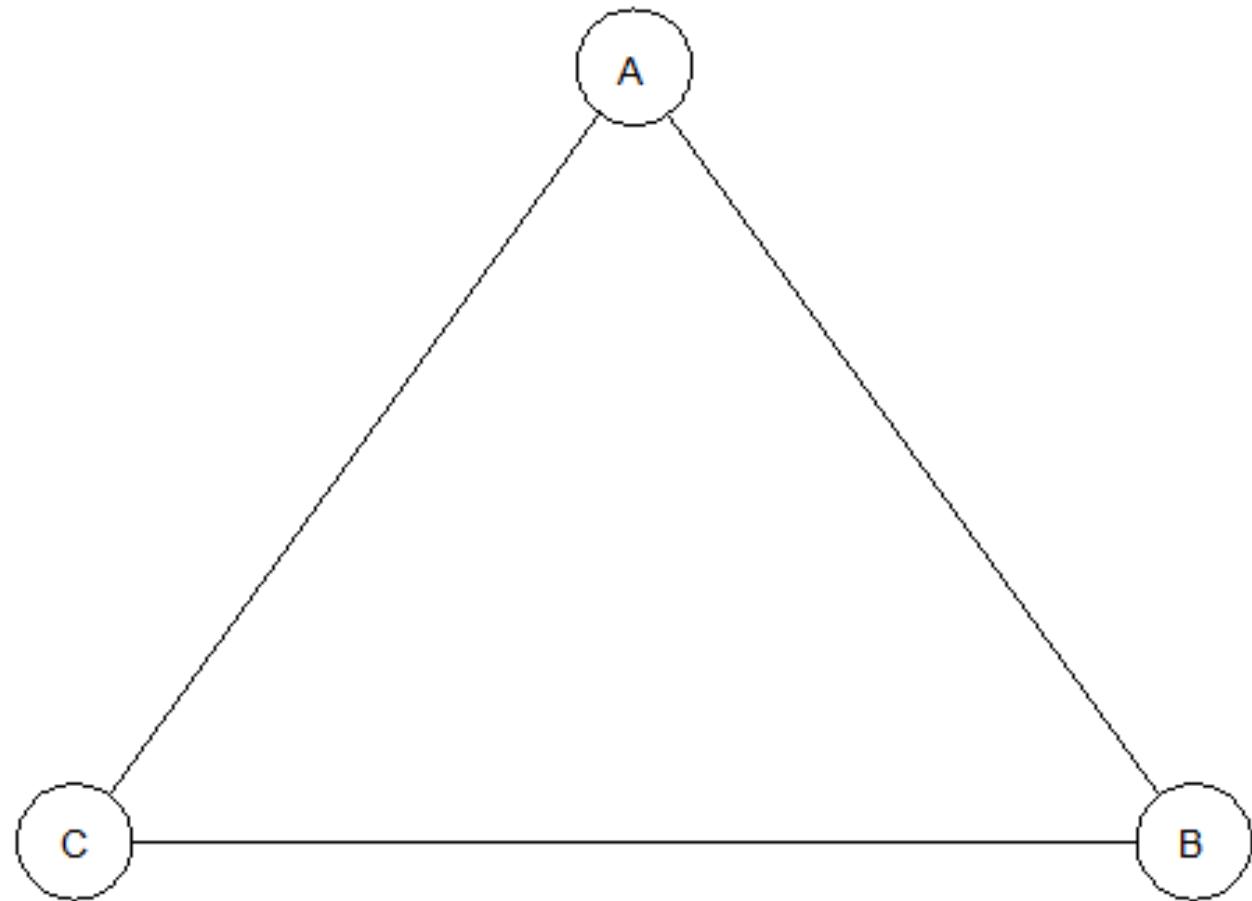
- Topologia

# Rede – representação gráfica

- Vértices (nodos, pontos)
  - Variáveis ou observações
- Arestas (linhas, conectores)

Ponderada	Direcional
Non ponderada	Non direcional





- Aresta (linha)

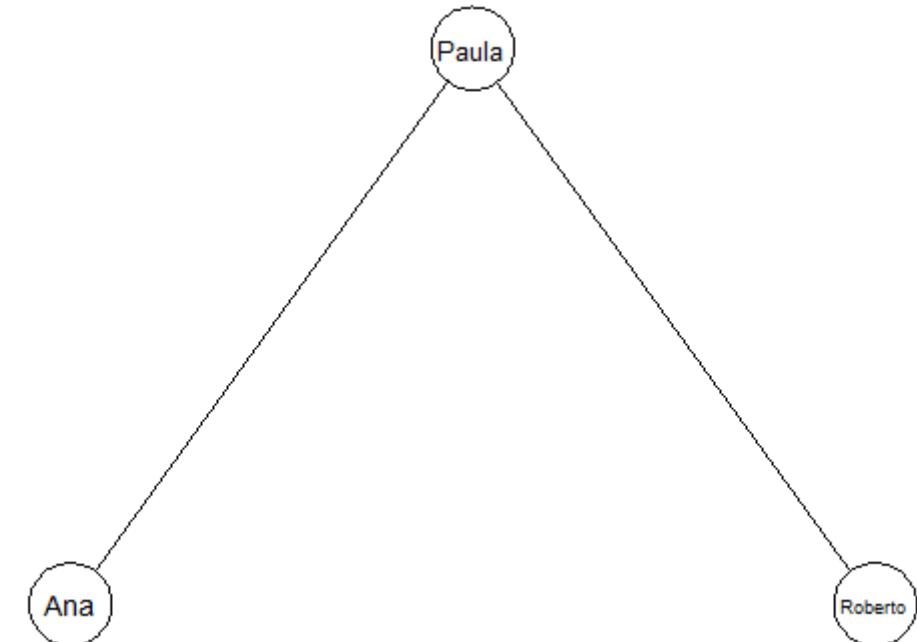
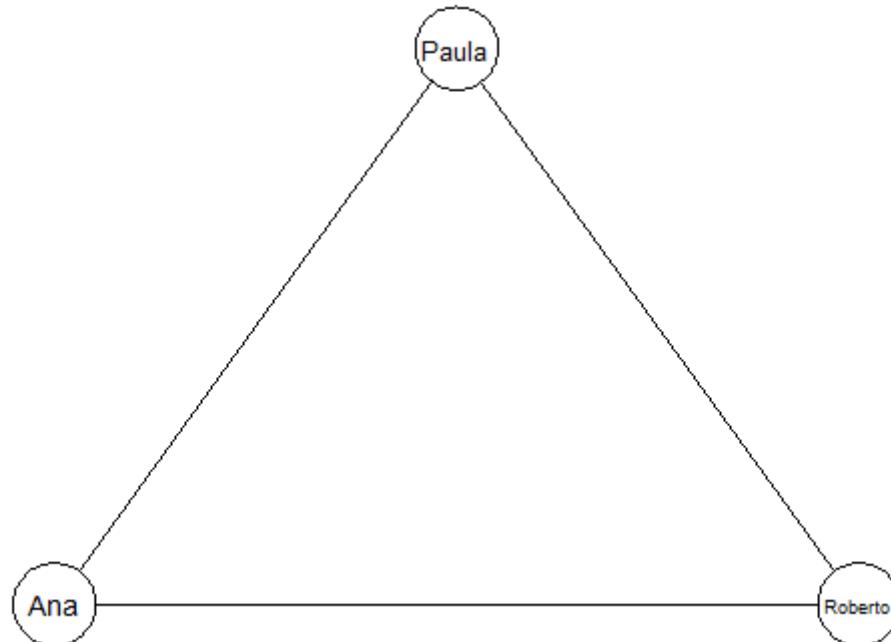
Quais tipo de dados  
representar?

# Amizades

	Paula	Roberto	Ana
Paula	0	1	1
Roberto	1	0	0
Ana	1	0	0

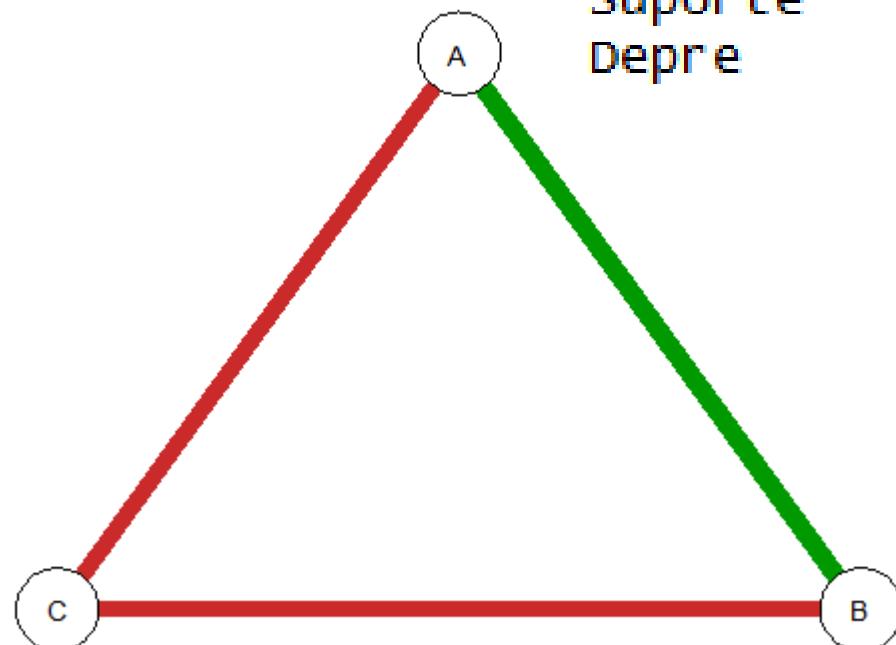
Cenário 1: Paula, Ana e Roberto são amigos

Cenário 2: Paula é amiga de Ana, Paula é amiga de Roberto, Ana e Roberto não são amigos

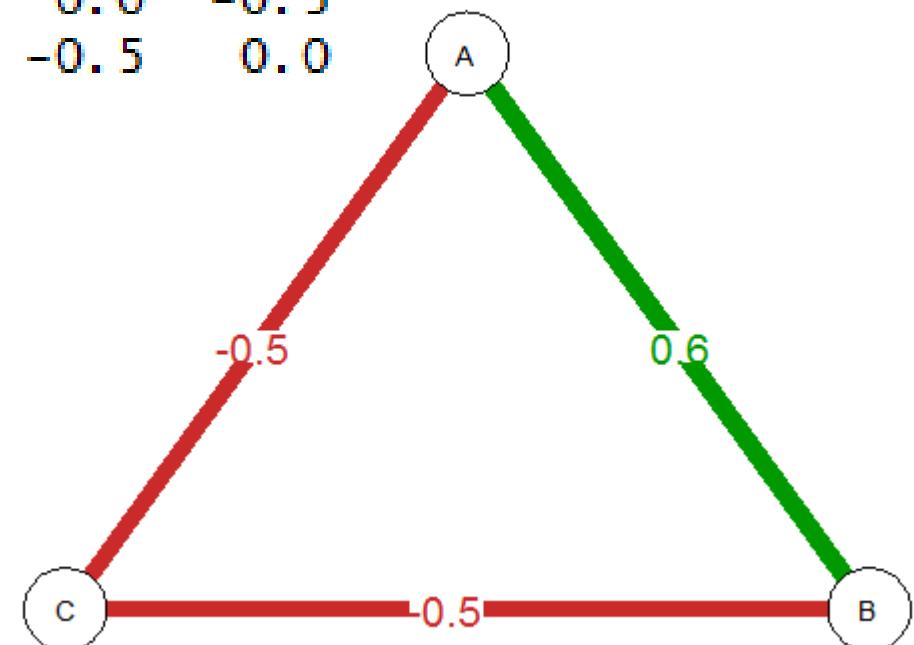


# Medidas de associação entre variáveis

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

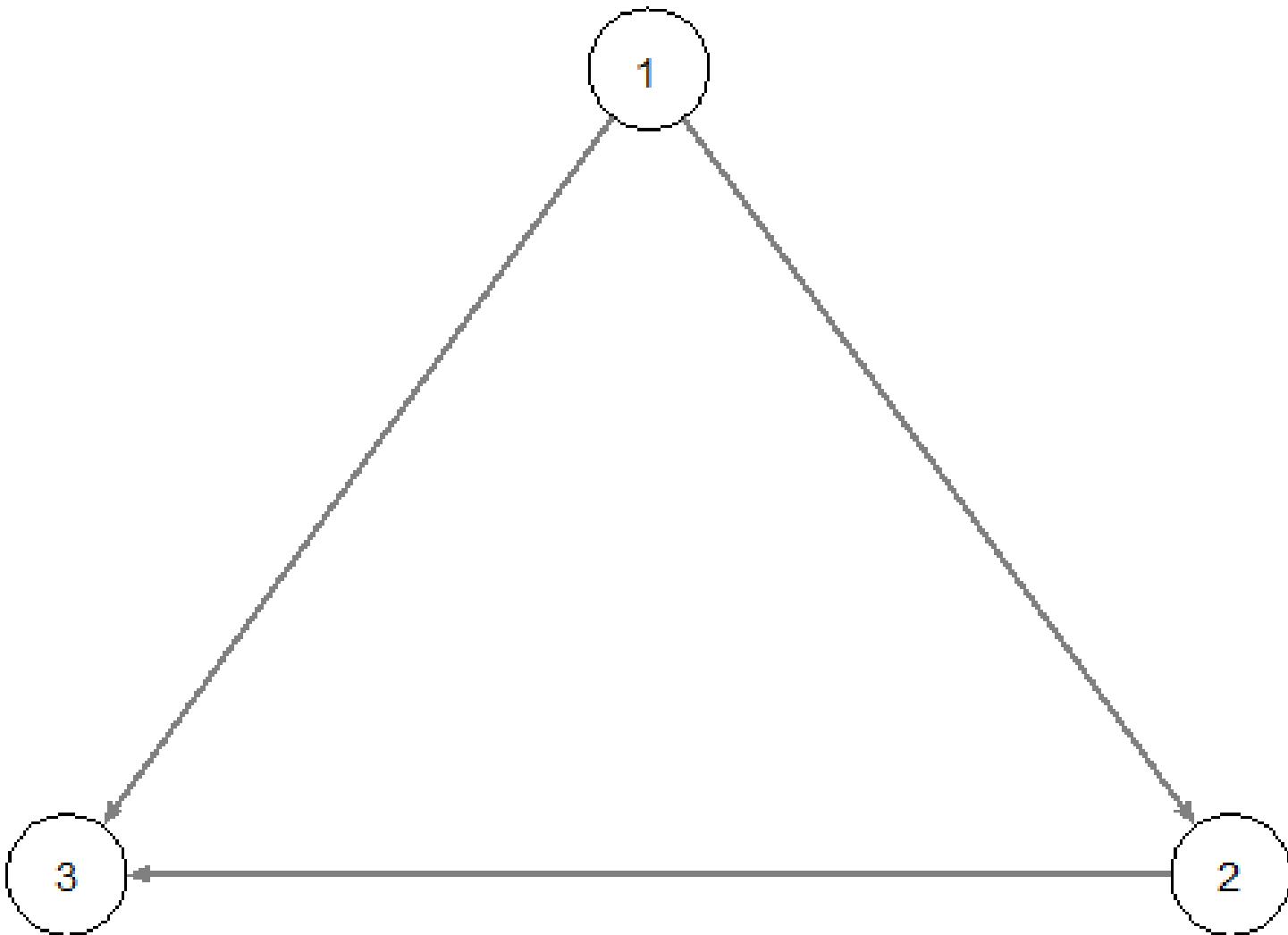


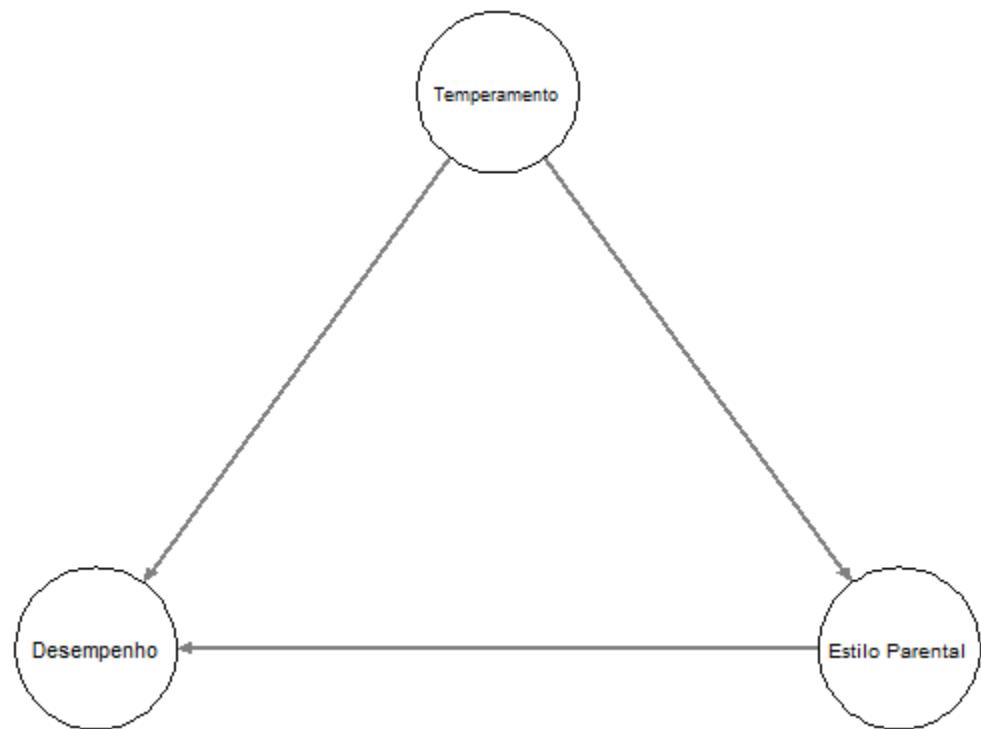
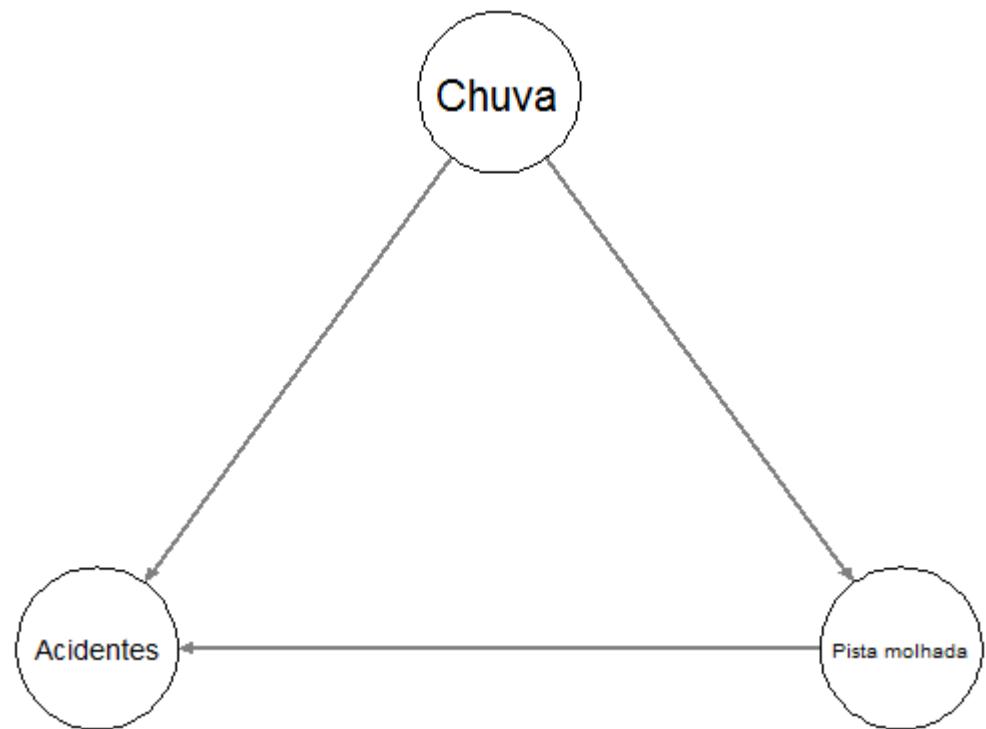
	Bem-estar	Suporte	Depre
Bem-estar	0.0	0.6	-0.5
Suporte	0.6	0.0	-0.5
Depre	-0.5	-0.5	0.0

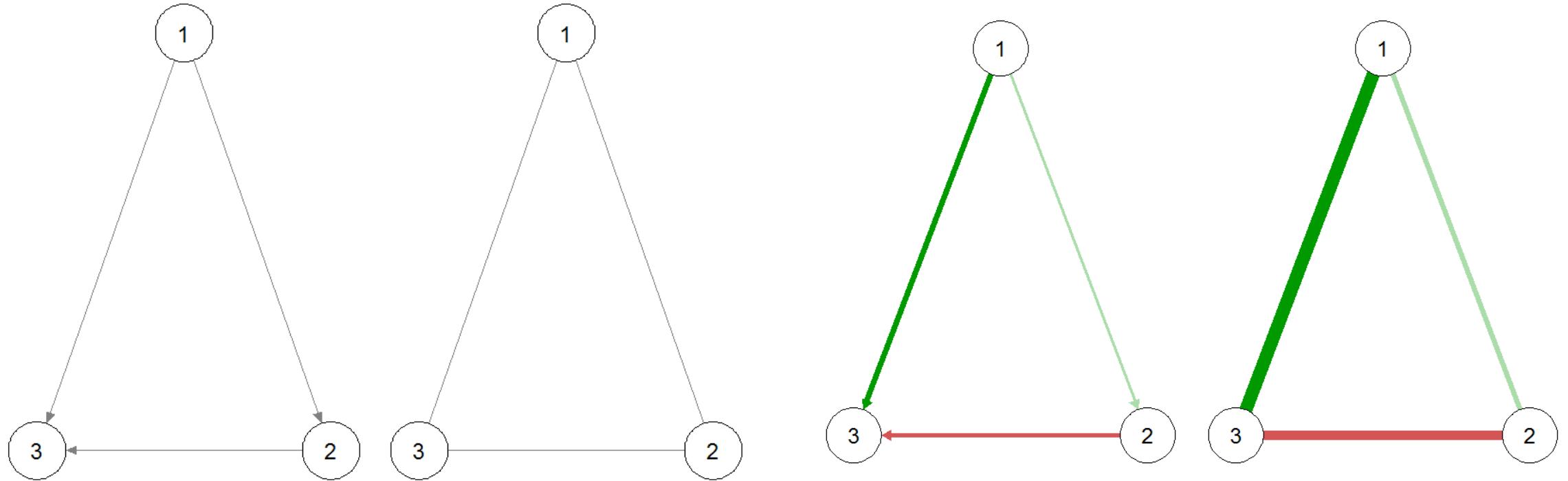


# Lista de arestas

	from	to
1	1	2
2	1	3
3	2	3

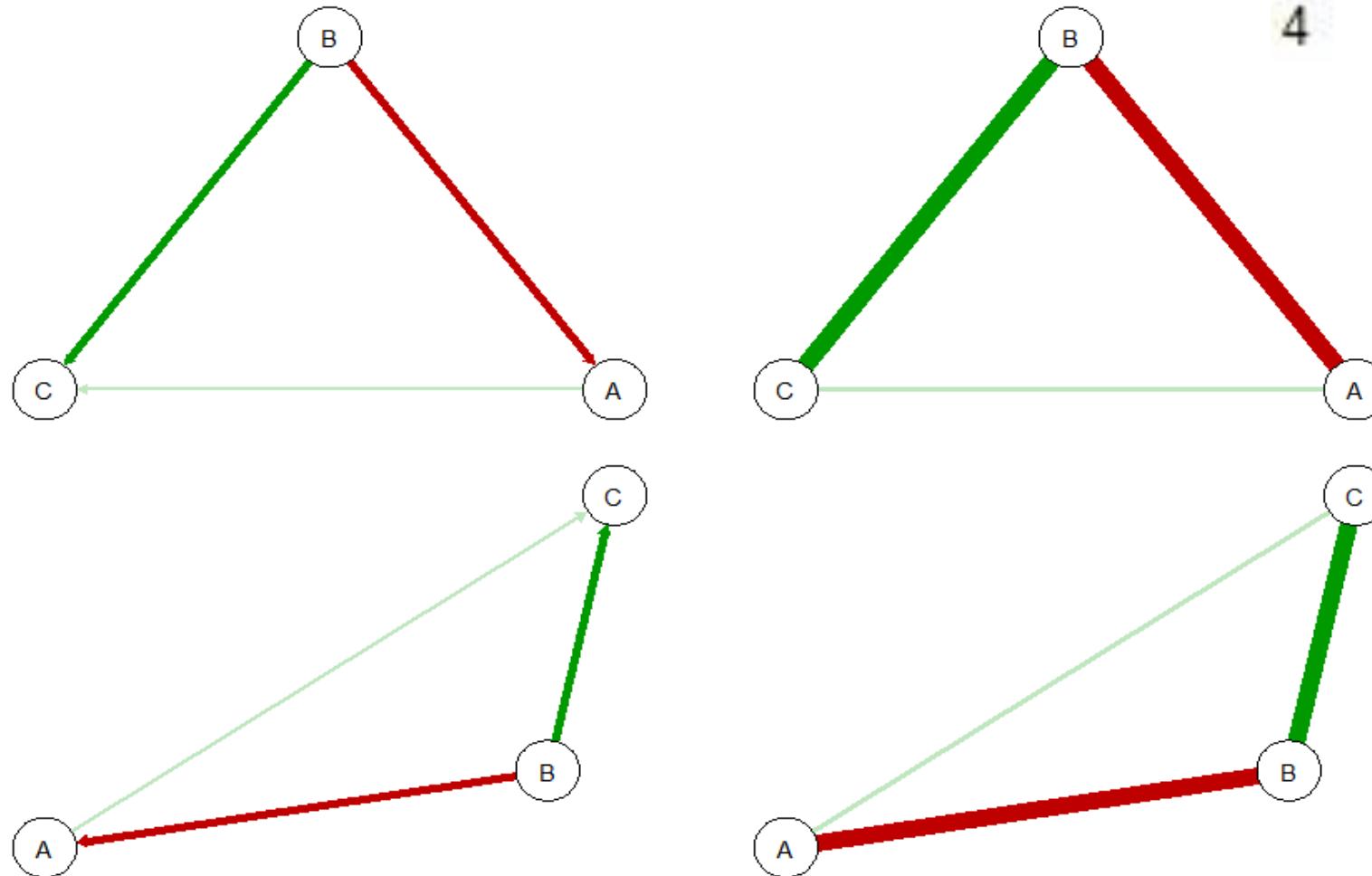




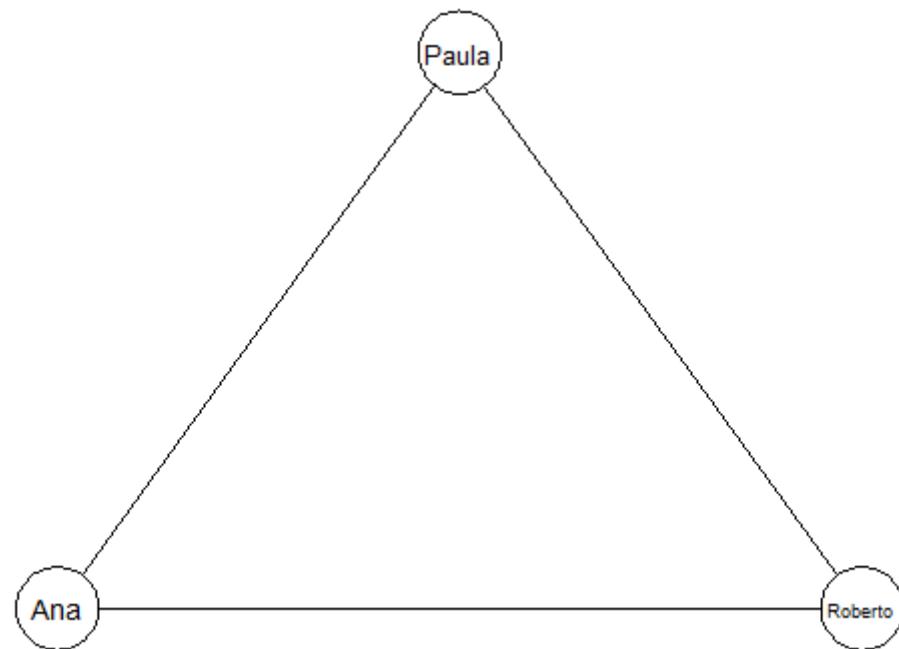


# Fruchterman & Reingold, 1991

	from	to	weight
1	B	A	-2.0
2	A	C	0.5
3	B	C	2.0
4	A	A	0.0

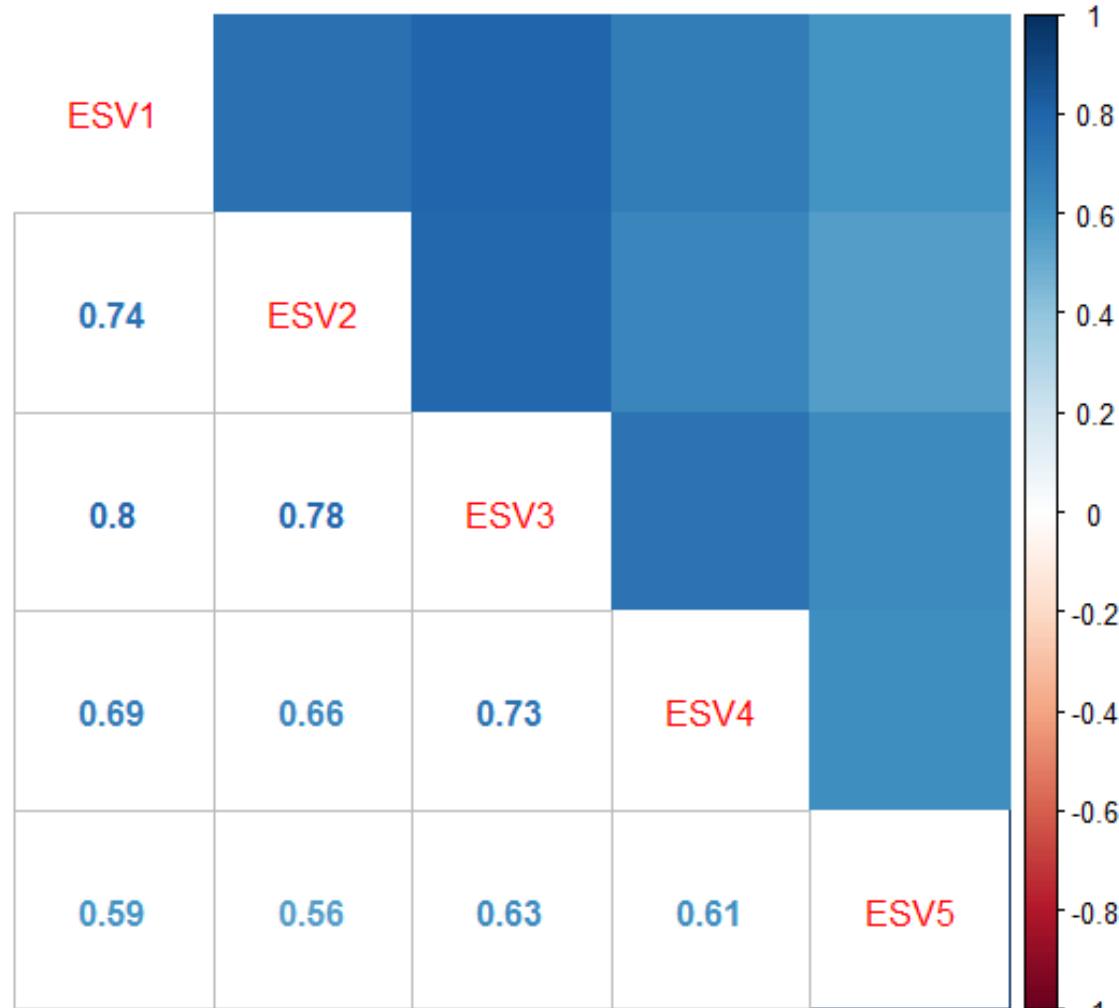


# Amizades

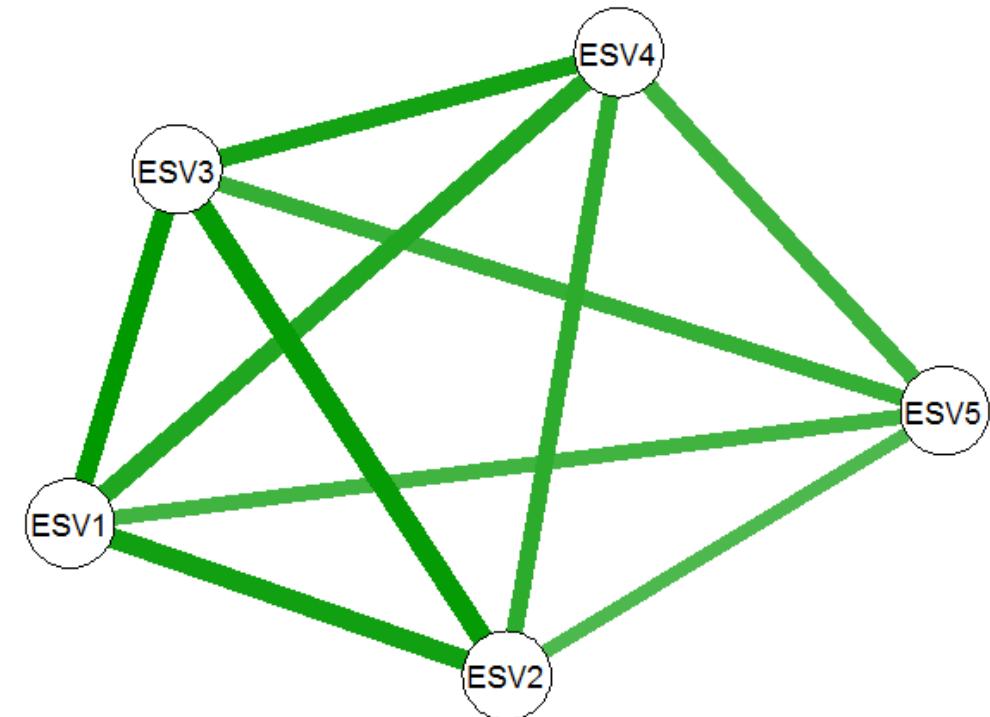
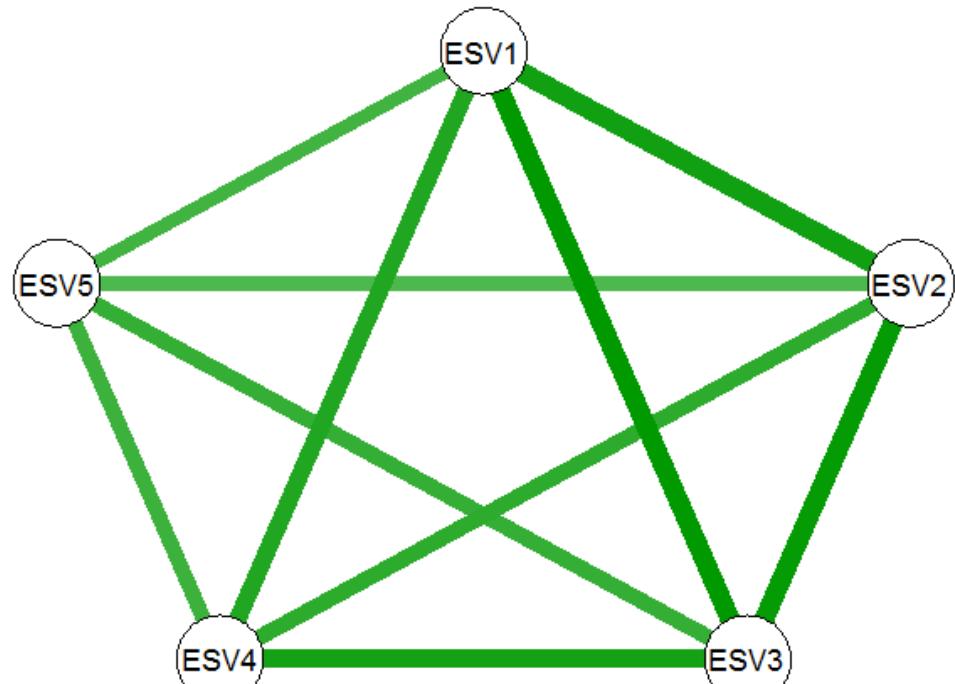


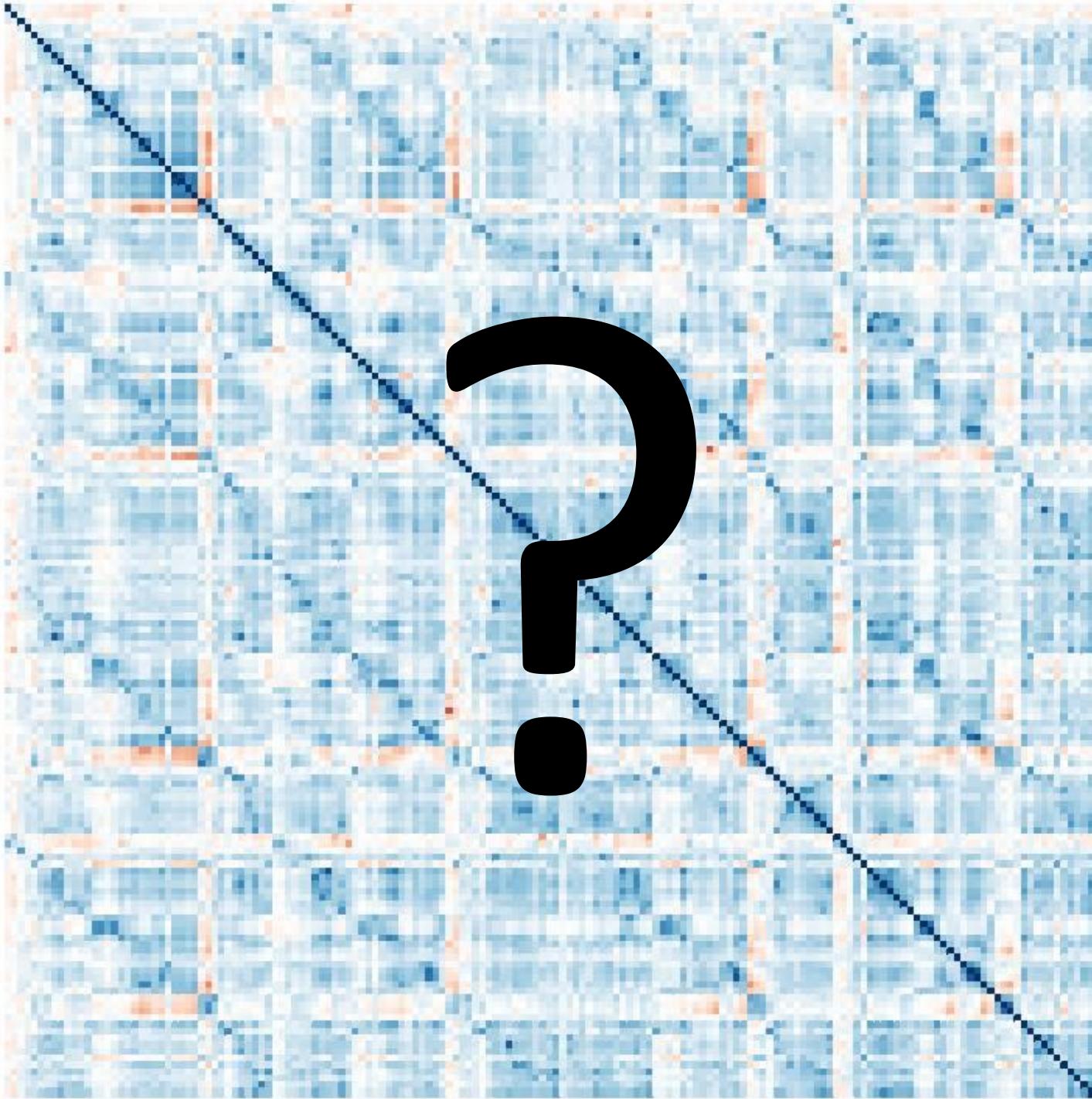
	Paula	Roberto	Ana
Paula	0	1	1
Roberto	1	0	0
Ana	1	0	0

# Escala de Satisfação com a Vida (Diener, Emmons, Larsen, & Griffin, 1985)



# Escala de Satisfação com a Vida (Diener, Emmons, Larsen, & Griffin, 1985)

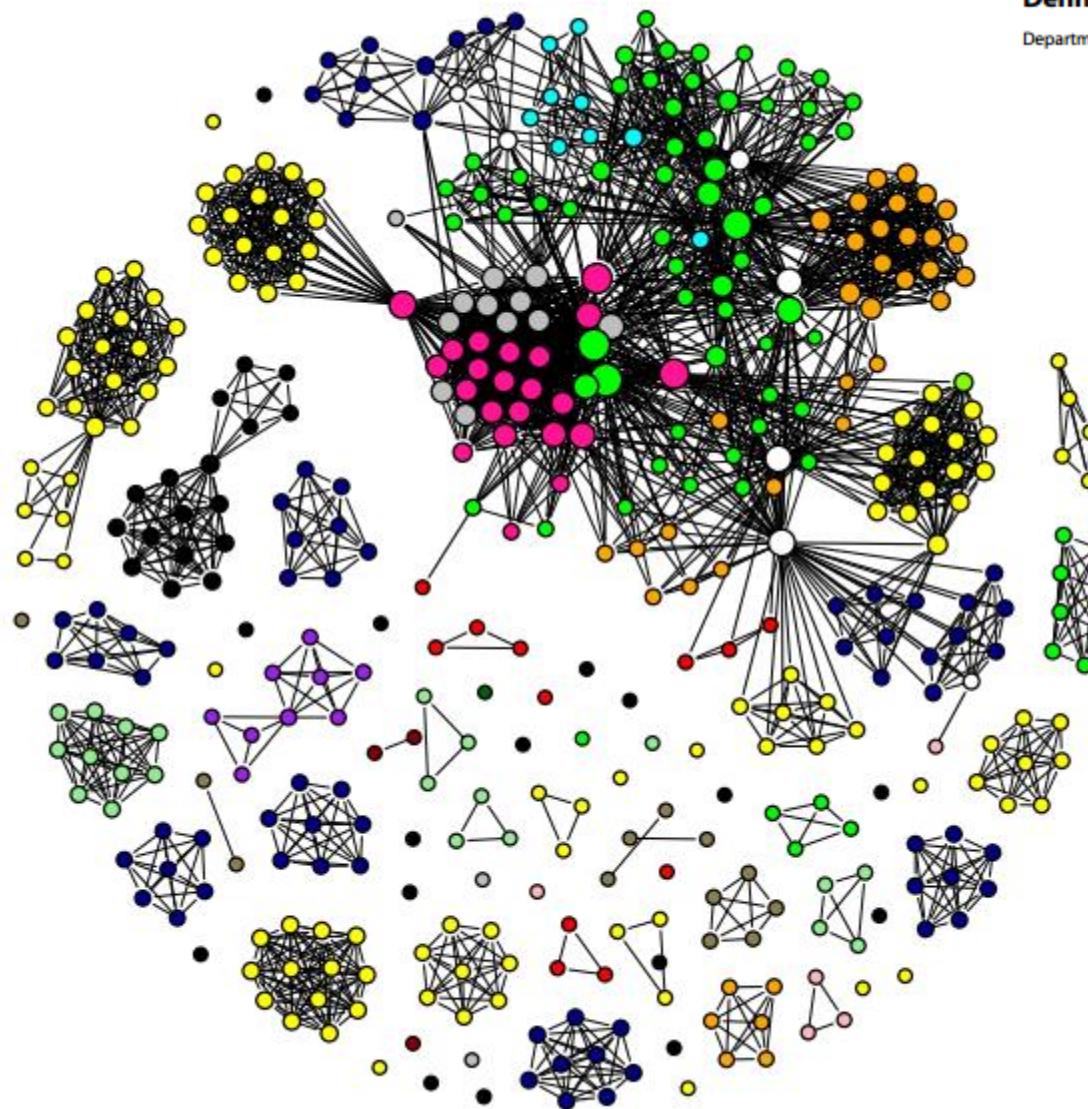




# The Small World of Psychopathology

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

Department of Psychology, University of Amsterdam, Amsterdam, The Netherlands



## Chapter of the DSM that feature the symptom the most

- Disorders usually first diagnosed in infancy, childhood or adolescence
- Delirium, dementia, and amnesia and other cognitive disorders
- Mental disorders due to a general 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
- Impulse control disorders not elsewhere classified
- Adjustment disorders
- Personality disorders
- Symptom is featured equally in multiple chapters

# Aplicações da análise de rede na Psicologia



Contents lists available at ScienceDirect

New Ideas in Psychology

journal homepage: [www.elsevier.com/locate/newideapsych](http://www.elsevier.com/locate/newideapsych)

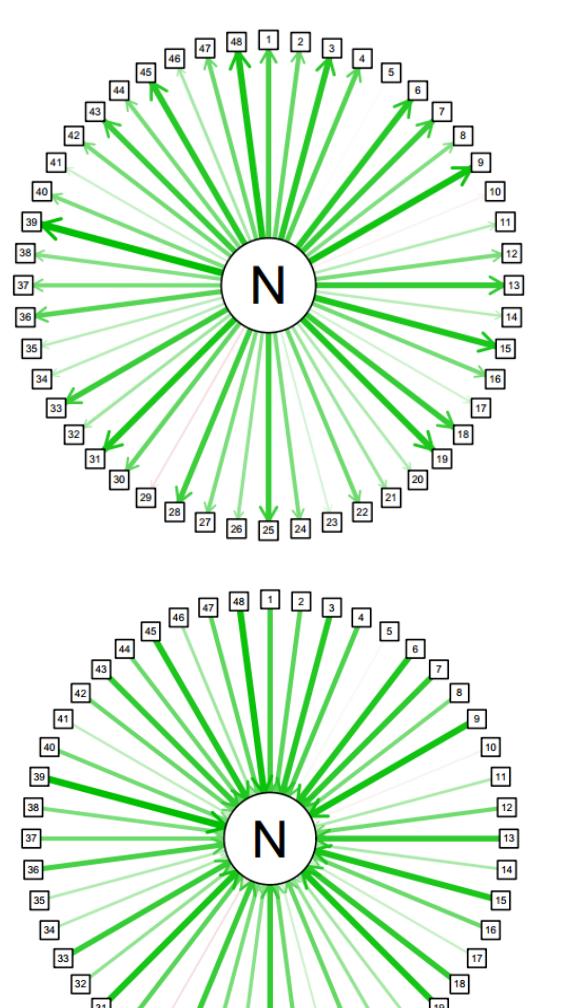
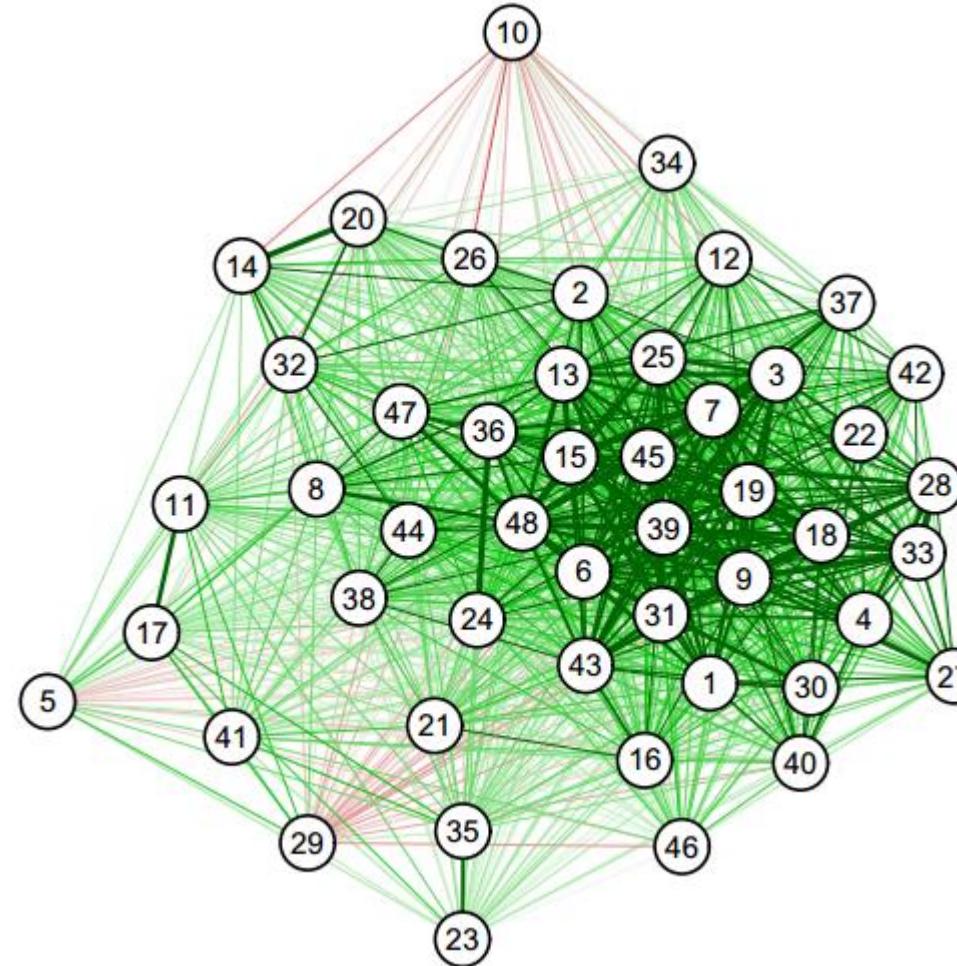


Deconstructing the construct: A network perspective  
on psychological phenomena

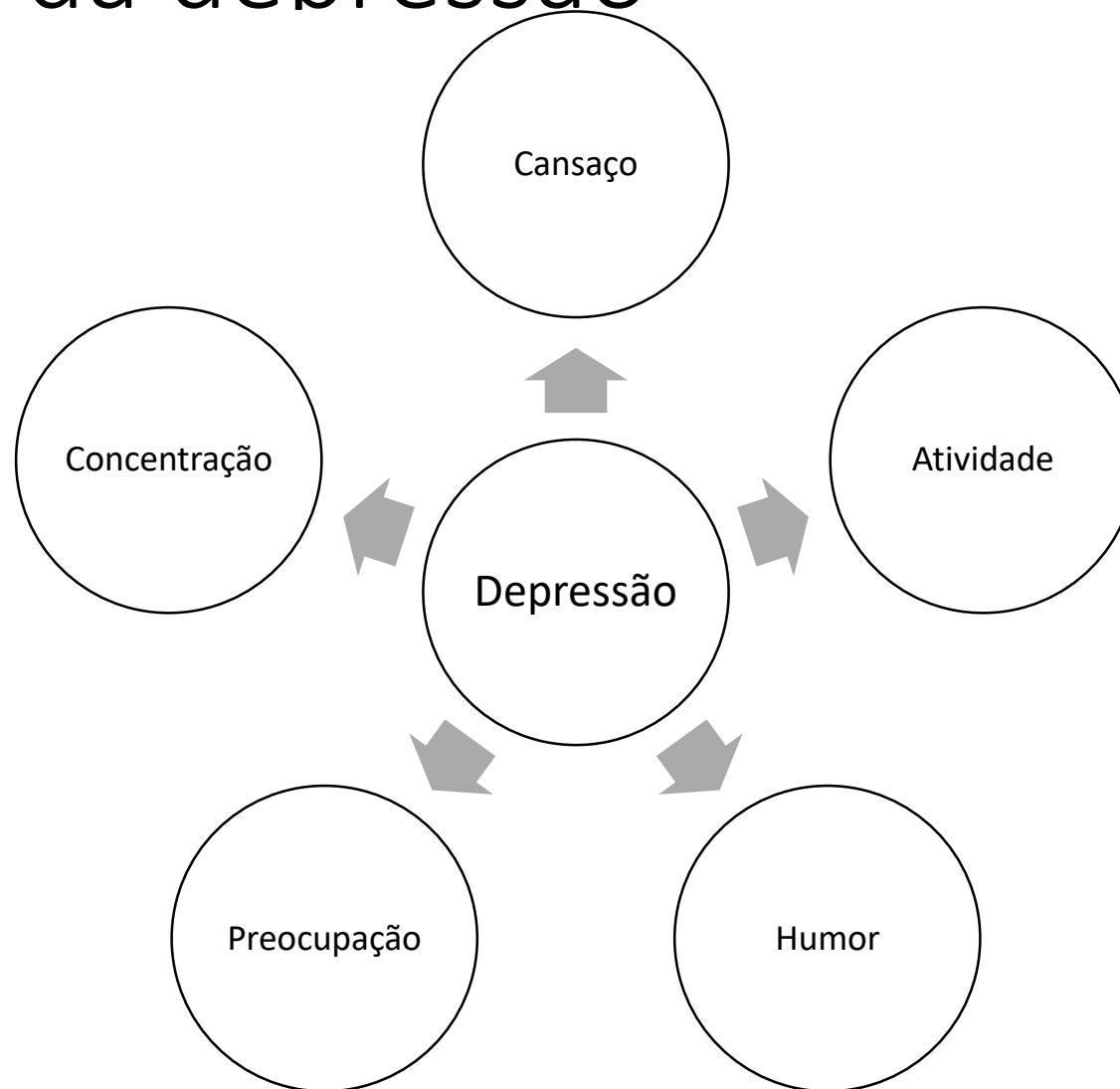
Verena D. Schmittmann, Angélique O.J. Cramer, Lourens J. Waldorp, Sacha Epskamp,  
Rogier A. Kievit, Denny Borsboom\*

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

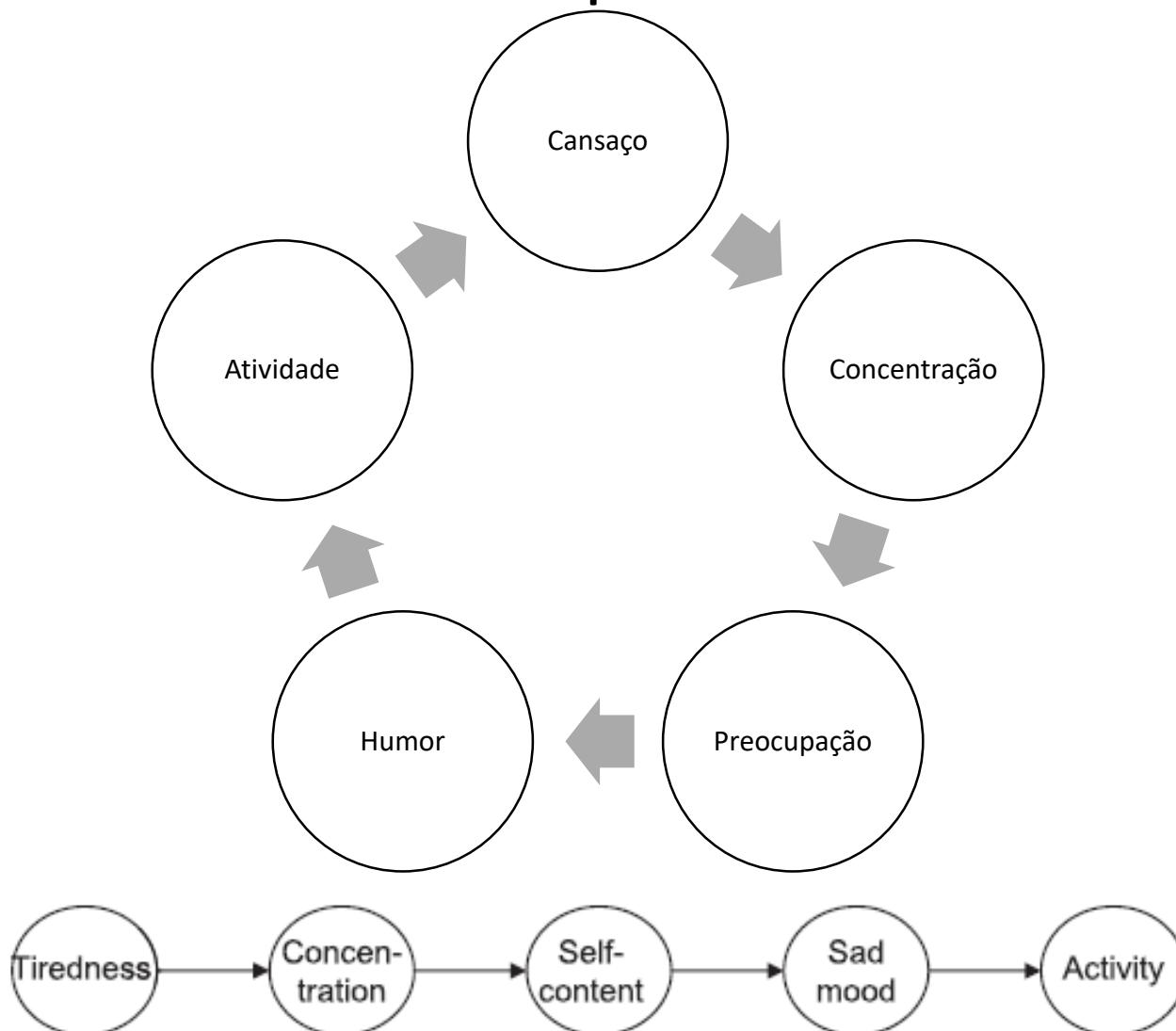
# Modelos reflexivo, formativo e de rede do traço neuroticismo



# Modelo atual da depressão



# Modelo alternativo da depressão



**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).

# Comorbidity: A network perspective

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Han L. J. van der Maas

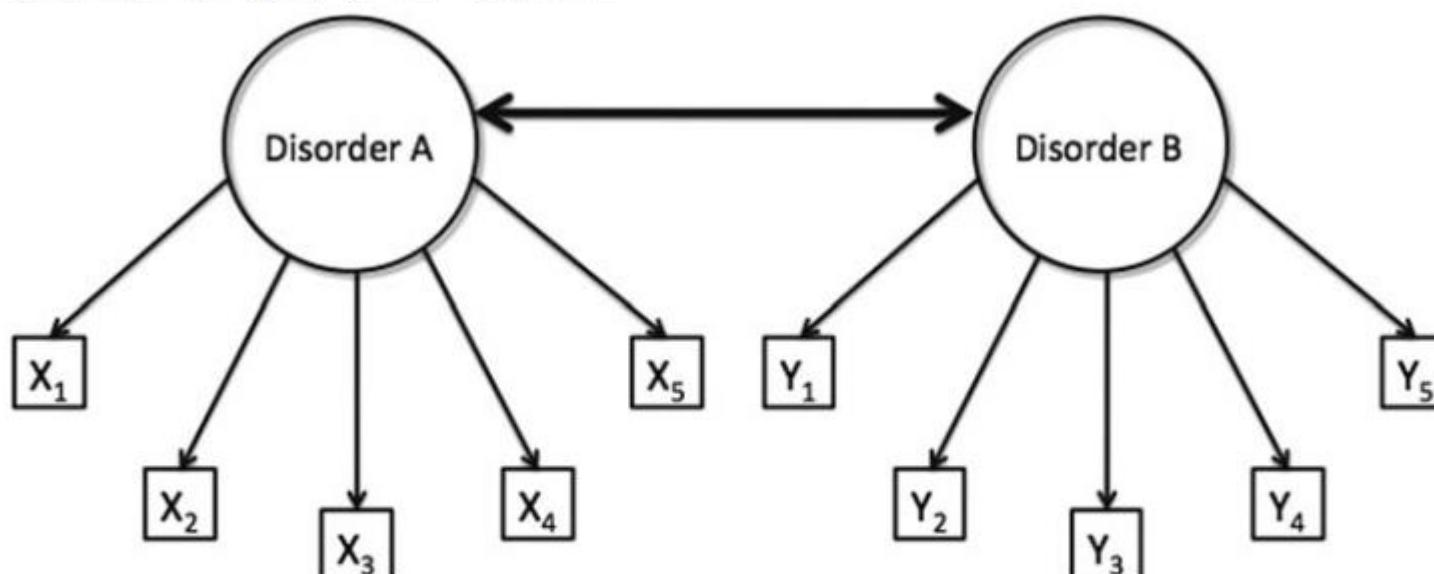


Figure 1. A model of comorbidity between disorders A and B, under the standard assumptions of latent variable modeling. The *circles* represent the disorders (i.e., latent variables) and the *rectangles* represent the observable core symptoms of those disorders (i.e.,  $X_1 - X_5$  for disorder A, and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

# Comorbidity: A network perspective

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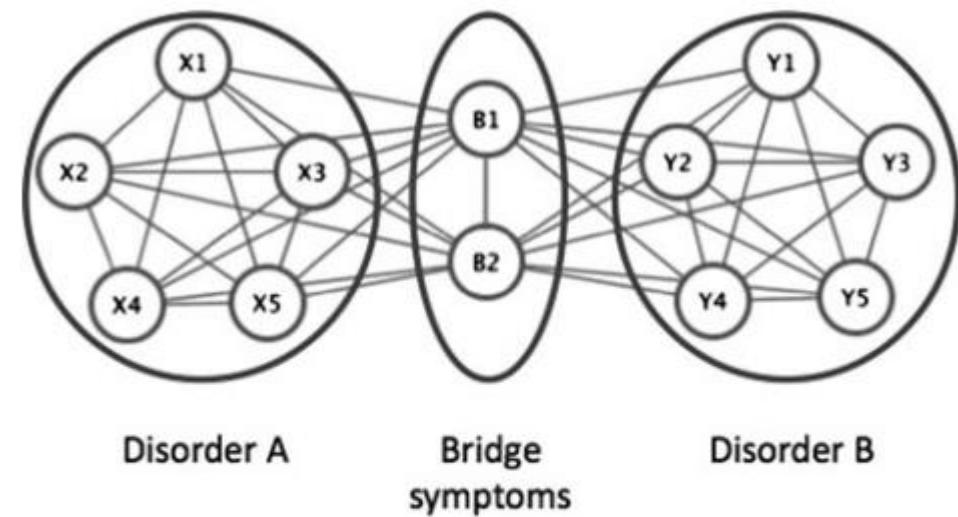
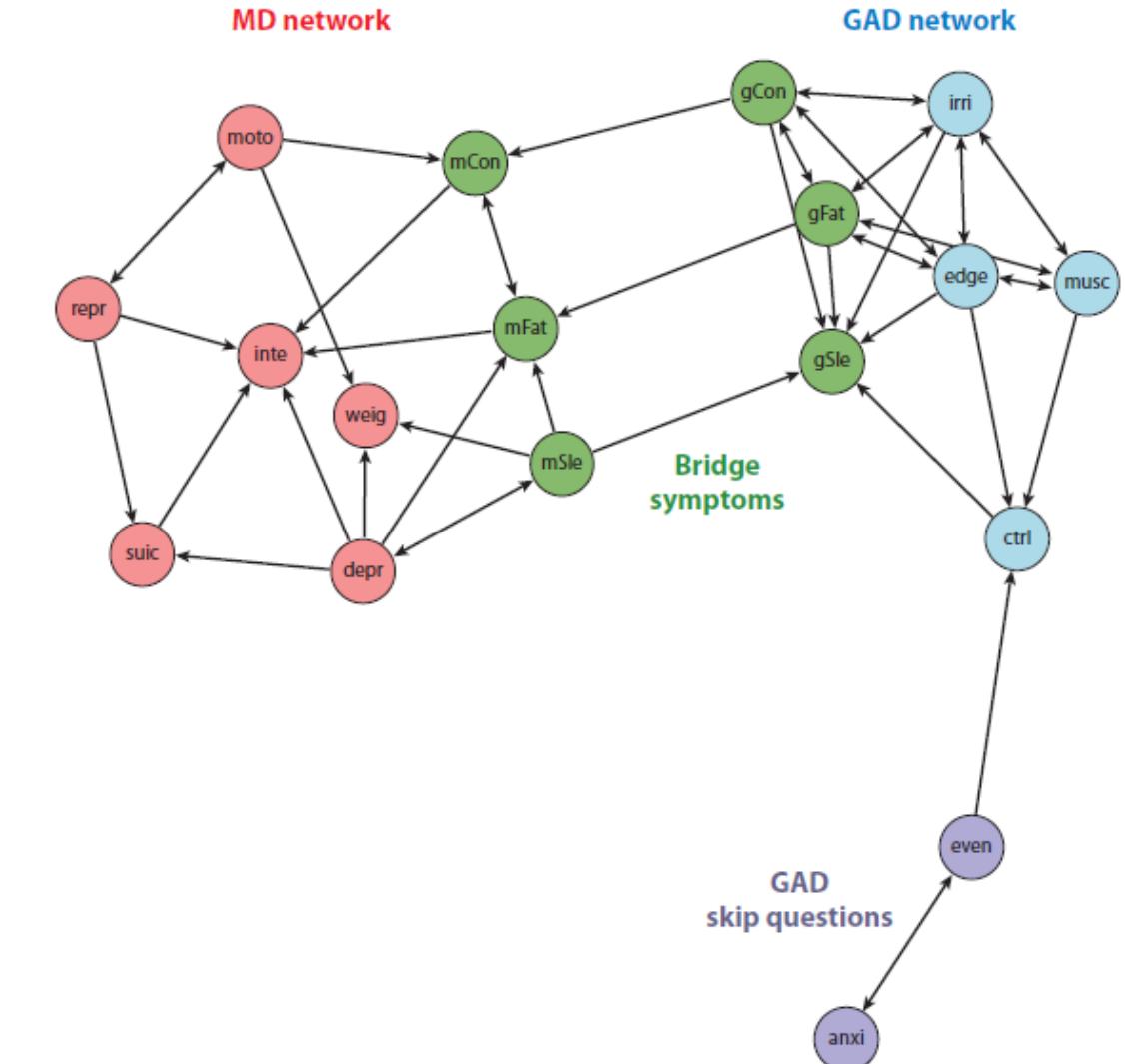


Figure 2. Comorbidity under a network approach. Disorder A consists of bidirectionally related symptoms  $X_1 - X_5$ , and disorder B consists of symptoms  $Y_1 - Y_5$ . Symptoms  $B_1$  and  $B_2$  are *bridge symptoms* that overlap between disorders A and B. In this model, comorbidity arises as a result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

# Network Analysis: An Integrative Approach to the Structure of Psychopathology

Denny Borsboom and Angélique O.J. Cramer

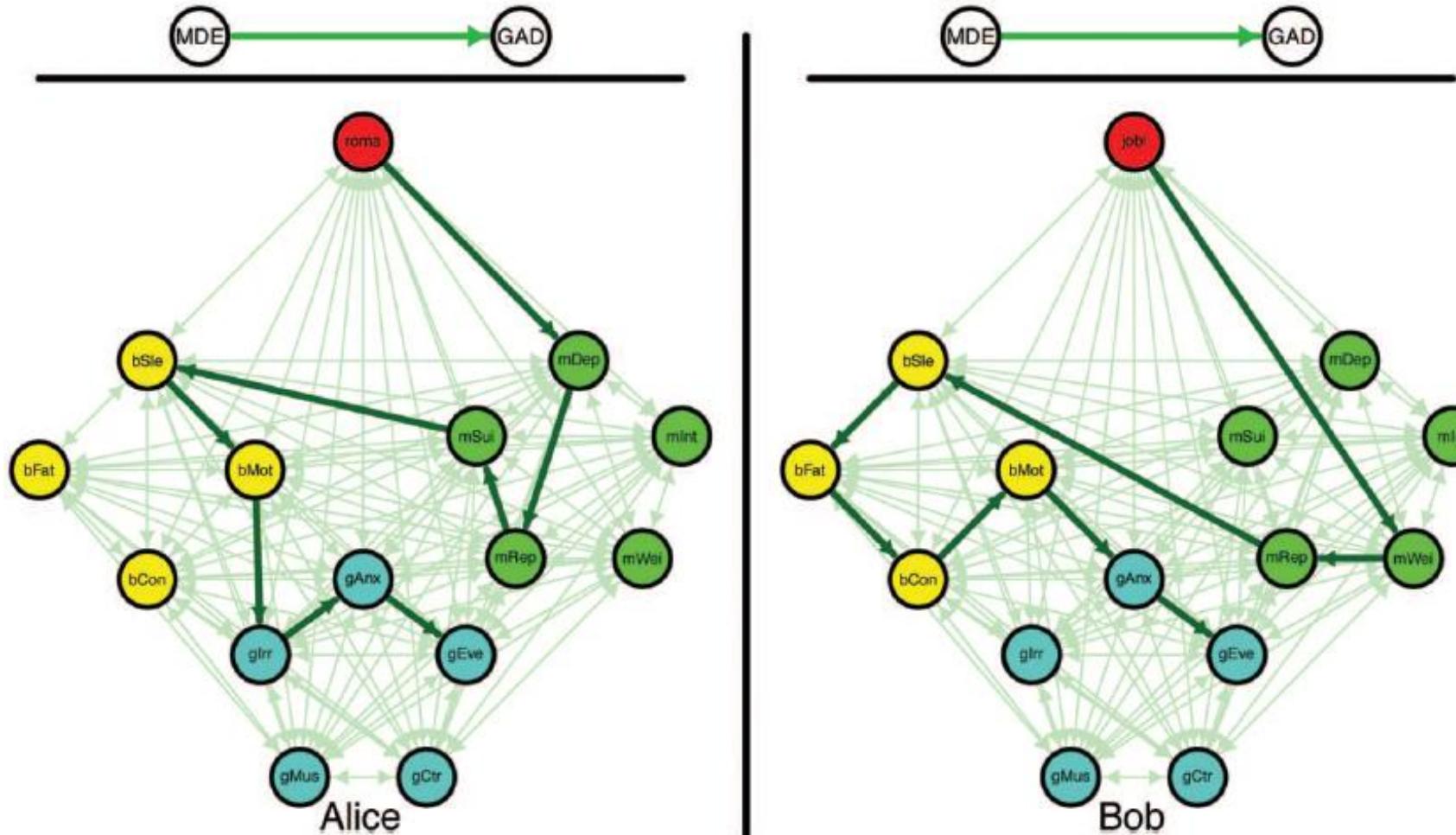
Department of Psychology, University of Amsterdam, Amsterdam 1018 XA, The Netherlands;  
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# The Small World of Psychopathology

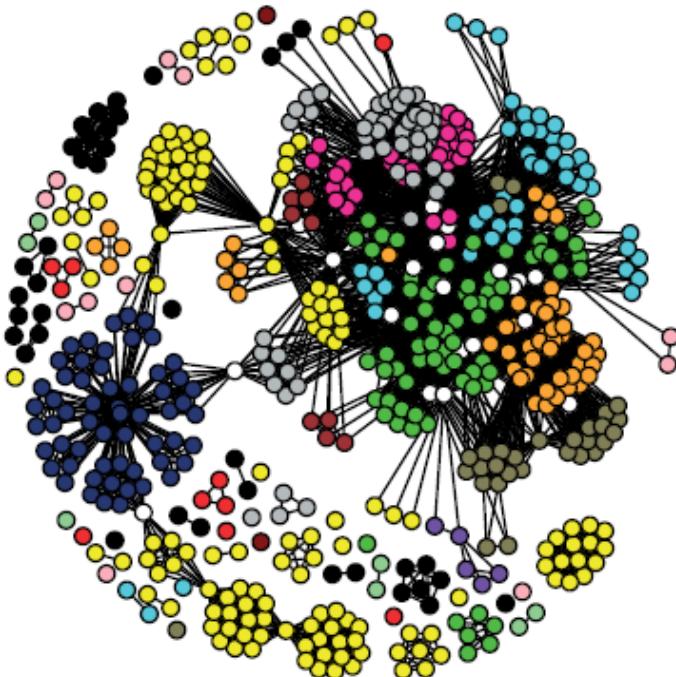
Denny Borsboom\*, Angélique O. J. Cramer, Verena D. Schmittmann, Sacha Epskamp, Lourens J. Waldorp

Department of Psychology, University of Amsterdam, Amsterdam, The Netherlands

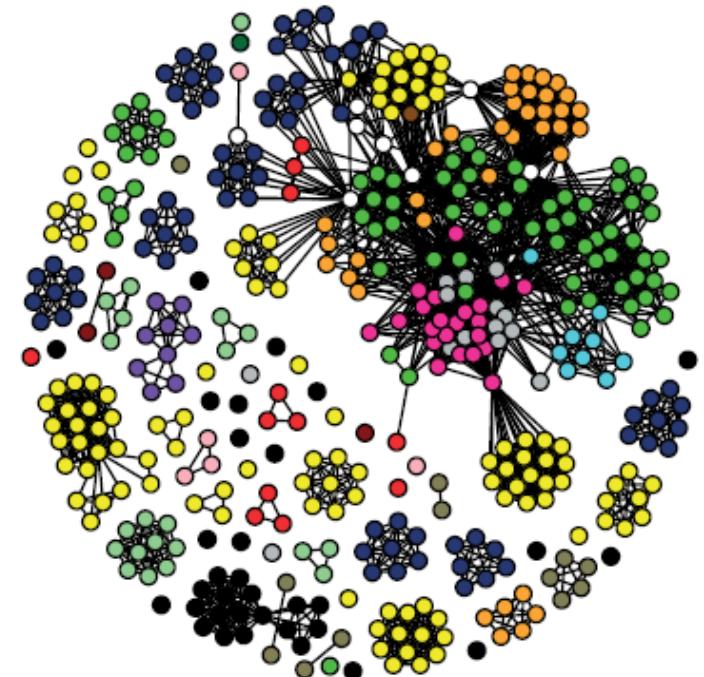


# Mapping the manuals of madness: Comparing the ICD-10 and DSM-IV-TR using a network approach

PIA TIO,<sup>1</sup> SACHA EPSKAMP,<sup>1</sup> ARJEN NOORDHOF<sup>2</sup> & DENNY BORSBOOM<sup>1</sup>



- 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
- Facitious 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



**Table 2.** Top 10 criteria with the highest degree for ICD-10 and DSM-IV-TR network

	ICD-10	DSM-IV-TR
1	Insomnia <sup>1</sup>	Insomnia <sup>1</sup>
2	Irritability <sup>1</sup>	Psychomotor agitation
3	Apathy	Psychomotor retardation <sup>1</sup>
4	Difficulty in concentrating <sup>1</sup>	Depressed
5	Nausea	Accelerated heart rate
6	Emotional lability	Distractibility
7	Sweating <sup>1</sup>	Irritability <sup>1</sup>
8	Chest pain	Anxiety and Hypersomnia
9	Restless sleep	Sweating <sup>1</sup> and Weight loss Difficulty in concentrating <sup>1</sup>
10	Psychomotor retardation <sup>1</sup>	and Hallucinations/illusions

<sup>1</sup>Criteria that occur in the top 10 of both networks. Places 8 through 10 in the DSM-IV-TR hold multiple symptoms.

Behav Genet (2014) 44:591–604  
DOI 10.1007/s10519-013-9625-7

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ORIGINAL RESEARCH

# The Big Five Personality Traits: Psychological Entities or Statistical Constructs?

Sanja Franić · Denny Borsboom · Conor V. Dolan ·  
Dorret I. Boomsma

## Dimensions of Normal Personality as Networks in Search of Equilibrium: You Can't Like Parties if You Don't Like People

ANGÉLIQUE O. J. CRAMER<sup>1\*</sup>, SOPHIE VAN DER SLUIS<sup>1,2</sup>, ARJEN NOORDHOF<sup>1</sup>, MARIEKE WICHERS<sup>3</sup>, NICOLE GESCHWIND<sup>3,4</sup>, STEVEN H. AGGEN<sup>5,6</sup>, KENNETH S. KENDLER<sup>5,6</sup> and DENNY BORSBOOM<sup>1</sup>

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<sup>2</sup>Complex Trait Genetics, Department of Functional Genomics and Department Clinical Genetics, Center for Neurogenomics and Cognitive Research (CNCR), FALW-VUA, Neuroscience Campus Amsterdam, VU University Medical Center (VUmc), The Netherlands

<sup>3</sup>European Graduate School for Neuroscience, SEARCH, Department of Psychiatry and Psychology, Maastricht University Medical Centre, The Netherlands

<sup>4</sup>Research Group on Health Psychology, Centre for the Psychology of Learning and Experimental Psychopathology, University of Leuven, Belgium

<sup>5</sup>Virginia Institute for Psychiatric and Behavioral Genetics, USA

<sup>6</sup>Department of Psychiatry, Virginia Commonwealth University, USA

## Author's Response

## Measurable Like Temperature or Mereological Like Flocking? On the Nature of Personality Traits

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journal homepage: [www.elsevier.com/locate/jrp](http://www.elsevier.com/locate/jrp)



## State of the aRt personality research: A tutorial on network analysis of personality data in R

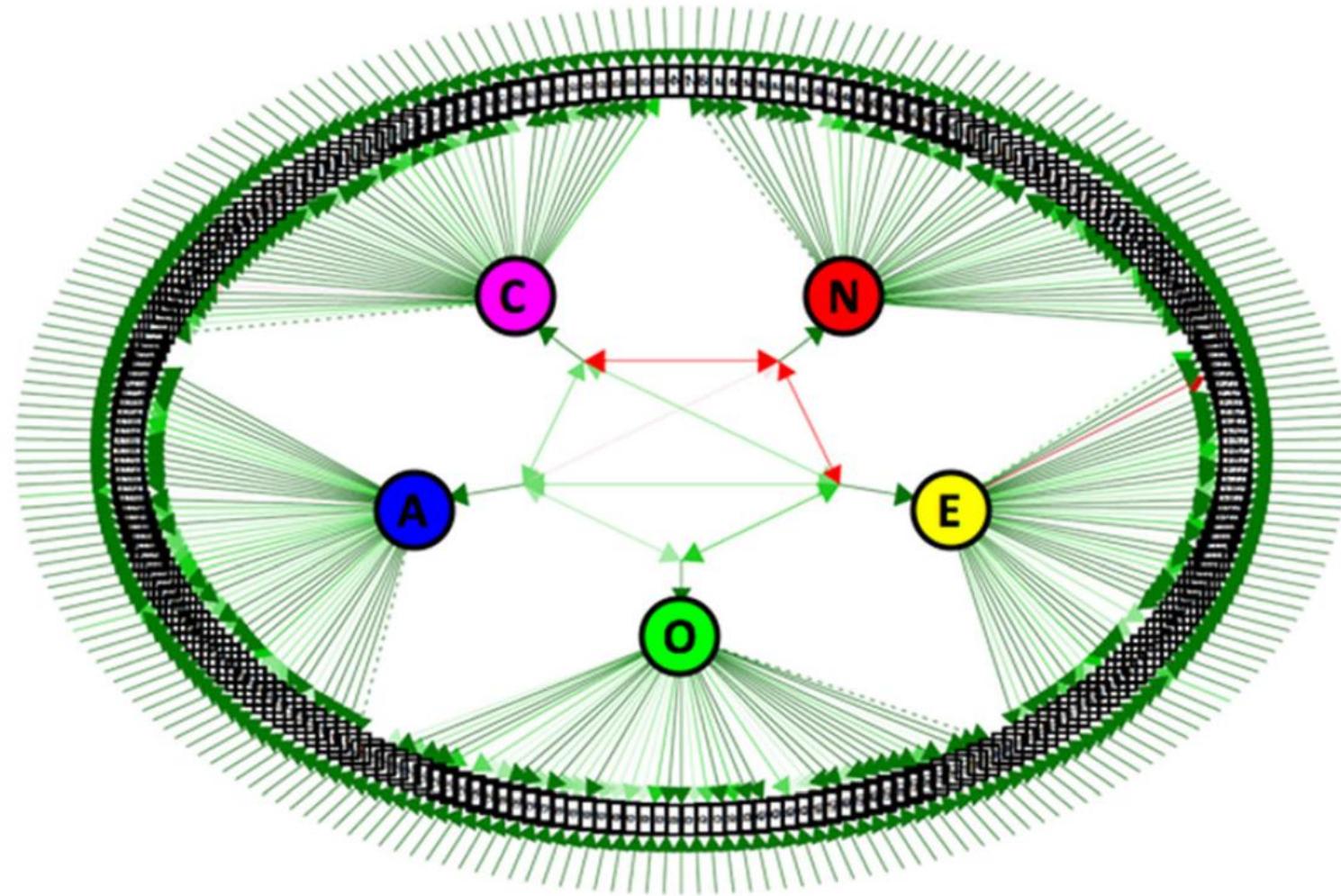
Giulio Costantini <sup>a,\*<sup>1</sup></sup>, Sacha Epskamp <sup>b,<sup>1</sup></sup>, Denny Borsboom <sup>b</sup>, Marco Perugini <sup>a</sup>, René Möttus <sup>c,d</sup>, Lourens J. Waldorp <sup>b</sup>, Angélique O.J. Cramer <sup>b</sup>

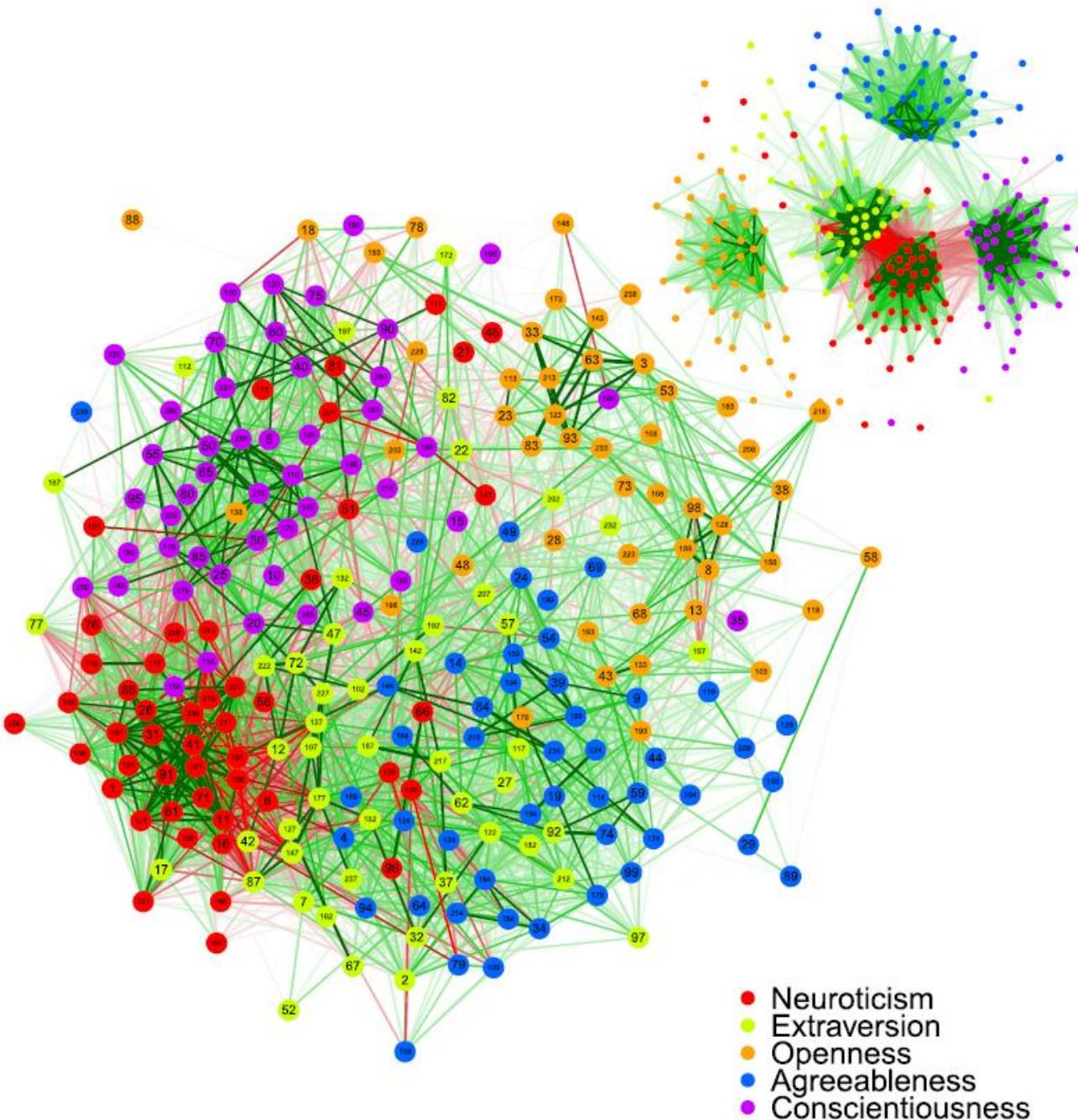
<sup>a</sup>Department of Psychology, University of Milan-Bicocca, Piazza dell'Ateneo Nuovo 1 (U6), 20126 Milan, Italy

<sup>b</sup>Department of Psychological Methods, University of Amsterdam, Weesperplein 4, 1018 XA Amsterdam, The Netherlands

<sup>c</sup>Department of Psychology, University of Edinburgh, George Square 7, EH8 9JZ Edinburgh, Scotland, UK

<sup>d</sup>Department of Psychology, University of Tartu, Näituse 2, 50409 Tartu, Estonia





Psychological Review  
2006, Vol. 113, No. 4, 842–861

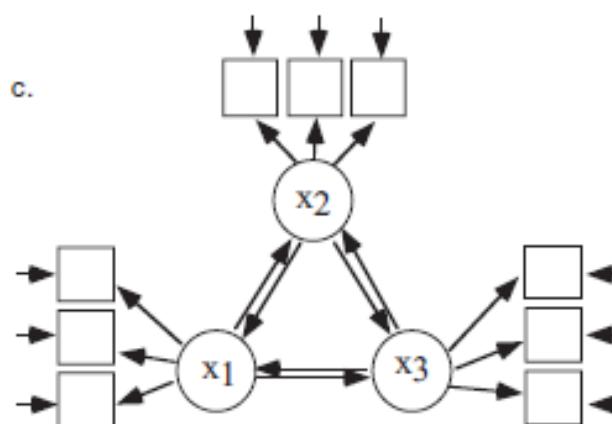
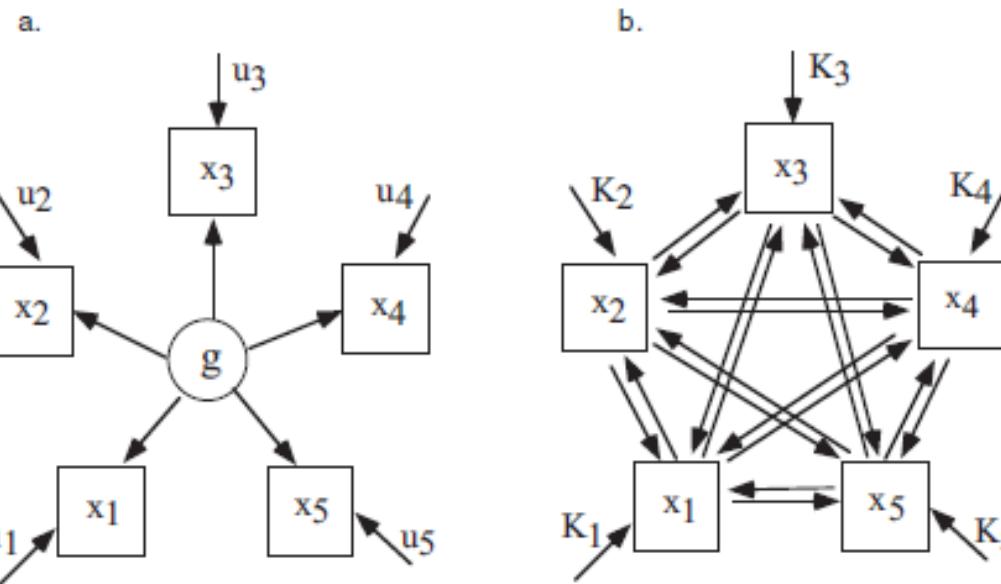
Copyright 2006 by the American Psychological Association  
0033-295X/06/\$12.00 DOI: 10.1037/0033-295X.113.4.842

## A Dynamical Model of General Intelligence: The Positive Manifold of Intelligence by Mutualism

Han L. J. van der Maas, Conor V. Dolan, Raoul P. P. P. Grasman, Jelte M. Wicherts,

Hilde M. Huizenga, and Maartje E. J. Raijmakers

University of Amsterdam



*Figure 1.* Three models of the positive manifold: (a) the standard  $g$  model, (b) the mutualism model, and (c) the extended mutualism model. Squares and circles denote manifest and latent variables, respectively. Symbols  $x$  denote processes,  $u$  unique variances, and  $K$  resources (see text).

*Measurement*, 6: 25–53, 2008  
Copyright © Taylor & Francis Group, LLC  
ISSN 1536-6367 print / 1536-6359 online  
DOI: 10.1080/15366360802035497



*Psychological Review*  
2004, Vol. 111, No. 4, 1061–1071

Copyright 2004 by the American Psychological Association  
0033-295X/04/\$12.00 DOI: 10.1037/0033-295X.111.4.1061

## Latent Variable Theory

Denny Borsboom  
*University of Amsterdam*

*Psychological Review*  
2003, Vol. 110, No. 2, 203–219

### The Theoretical Status of Latent Variables

Denny Borsboom, Gideon J. Mellenbergh, and Jaap van Heerden  
*University of Amsterdam*

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0033-295X/03/\$12.00 DOI: 10.1037/0033-295X.110.2.203



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### New Ideas in Psychology

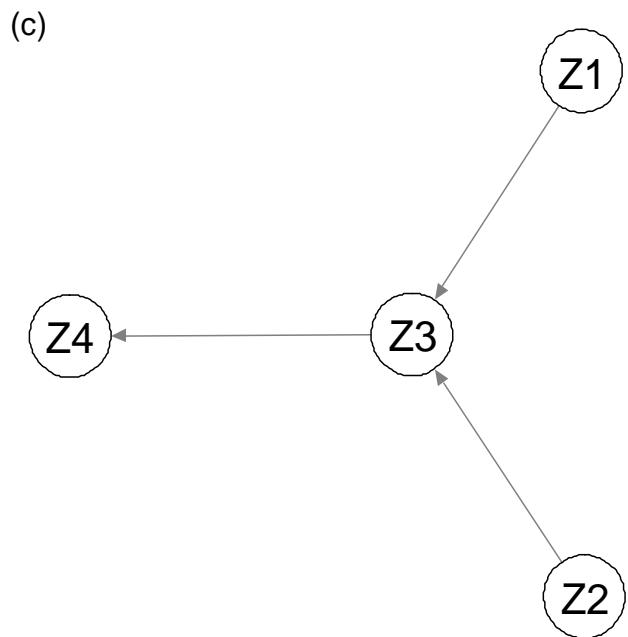
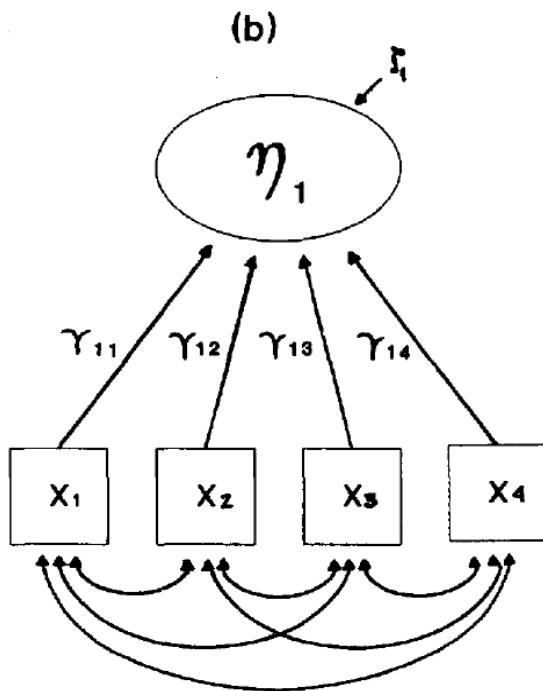
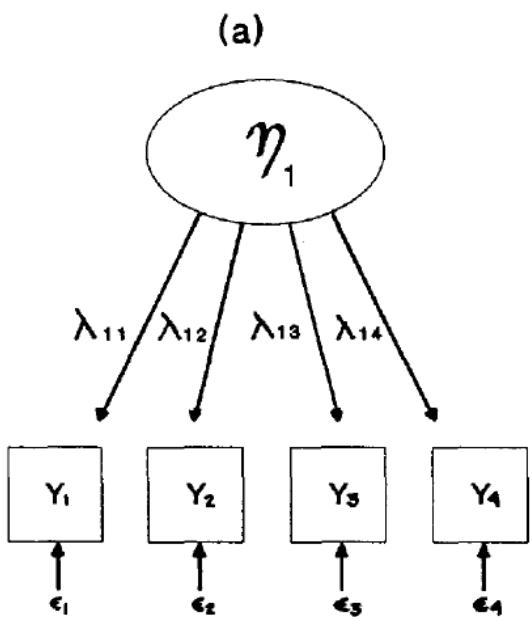
journal homepage: [www.elsevier.com/locate/newideapsych](http://www.elsevier.com/locate/newideapsych)



### 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*



# **Psychological Assessment**

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

Eiko I. Fried, Claudia D. van Borkulo, Sacha Epskamp, Robert A. Schoevers, Francis Tuerlinckx, and Denny Borsboom

Online First Publication, January 28, 2016. <http://dx.doi.org/10.1037/pas0000275>

## **Problems Attract Problems: A Network Perspective on Mental Disorders**

Soc Psychiatry Psychiatr Epidemiol (2017) 52:1–10  
DOI 10.1007/s00127-016-1319-z

INVITED REVIEWS

ANGÉLIQUE O. J. CRAMER and DENNY BORSBOOM

## **Mental disorders as networks of problems: a review of recent insights**

Eiko I. Fried<sup>1</sup> · Claudia D. van Borkulo<sup>1,2</sup> · Angélique O. J. Cramer<sup>1</sup> ·  
Lynn Boschloo<sup>2</sup> · Robert A. Schoevers<sup>2</sup> · Denny Borsboom<sup>1</sup>

## Revealing the dynamic network structure of the Beck Depression Inventory-II

L. F. Bringmann<sup>1\*</sup>, L. H. J. M. Lemmens<sup>2</sup>, M. J. H. Huibers<sup>2,3</sup>, D. Borsboom<sup>4</sup> and F. Tuerlinckx<sup>1</sup>

<sup>1</sup>Faculty of Psychology and Educational Sciences, University of Leuven, Leuven, Belgium

<sup>2</sup>Department of Clinical Psychological Science, Maastricht University, Maastricht, The Netherlands

<sup>3</sup>Department of Clinical Psychology, VU University of Amsterdam, Amsterdam, The Netherlands

<sup>4</sup>Department of Psychology, University of Amsterdam, Amsterdam, The Netherlands

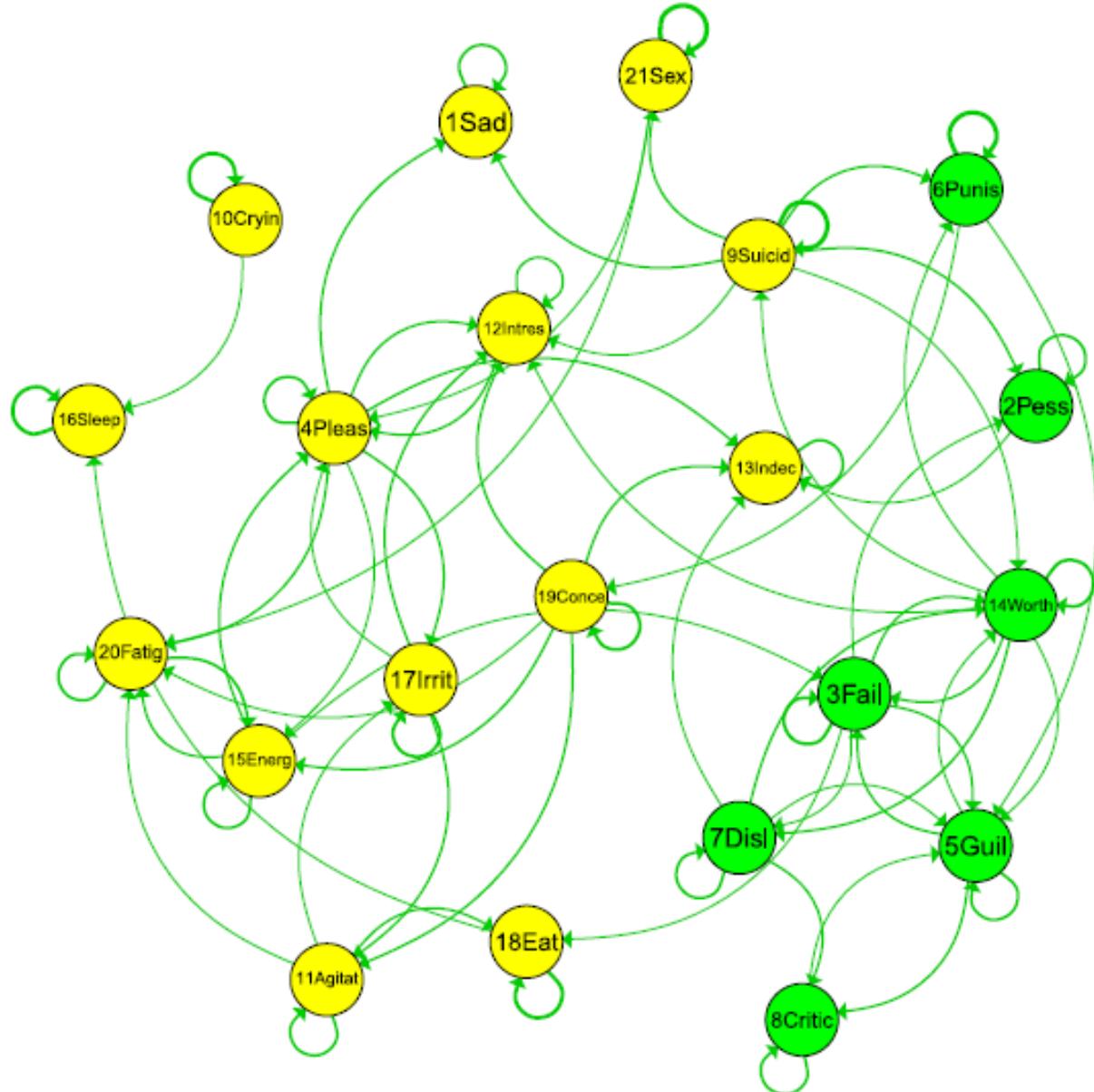
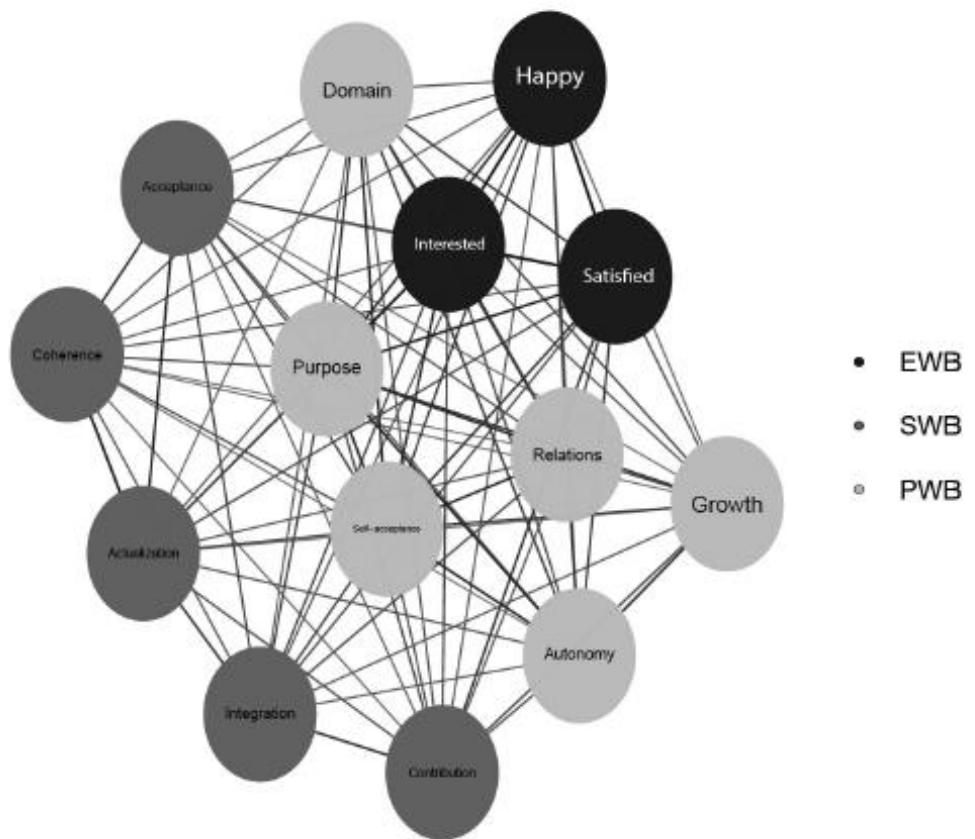


Fig. 3. Community structure of the BDI-II network with the two clusters indicated by two different colours.

Table 4  
*Centrality Indexes and Thresholds of the Network Elements*

Item (summarized content)	Centrality eigenvector*	$\tau$
1 – Happy	.90	-.77
2 – Interested	.96	-1.12
3 – Satisfied	.97	-.57
4 – Contribute to society	.84	-.24
5 – Belong to community	.85	-.26
6 – Society is becoming a better place	.85	.31
7 – People are good	.83	-.08
8 – Way society works makes sense	.79	.53
9 – Likes own personality	.97	-.54
10 – Manages responsibility well	.87	-.59
11 – Relationships with others	.90	-.81
12 – Grow and become a better person	.82	-.74
13 – Confident to express own ideas	.89	-.67
14 – Life has direction or meaning	1.00	-.80

Note. \*The unit represents the central node and follows a decreasing order until the most peripheral node.



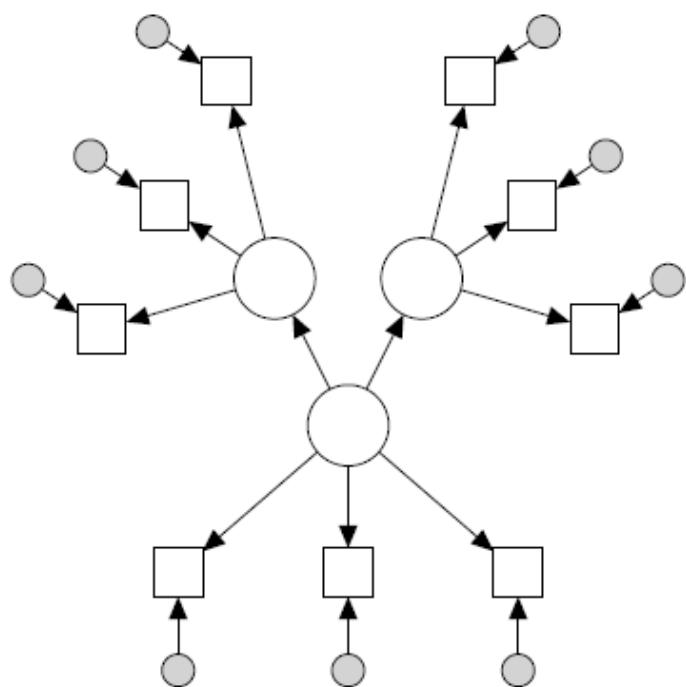
## Health Scale: Validation of the *Mental Health Continuum – Short Form*

Machado – Pontifícia Universidade Católica de Campinas, Campinas, São Paulo, Brasil  
 Michel Bandeira – Universidade Federal do Rio Grande do Sul, Porto Alegre, Brasil

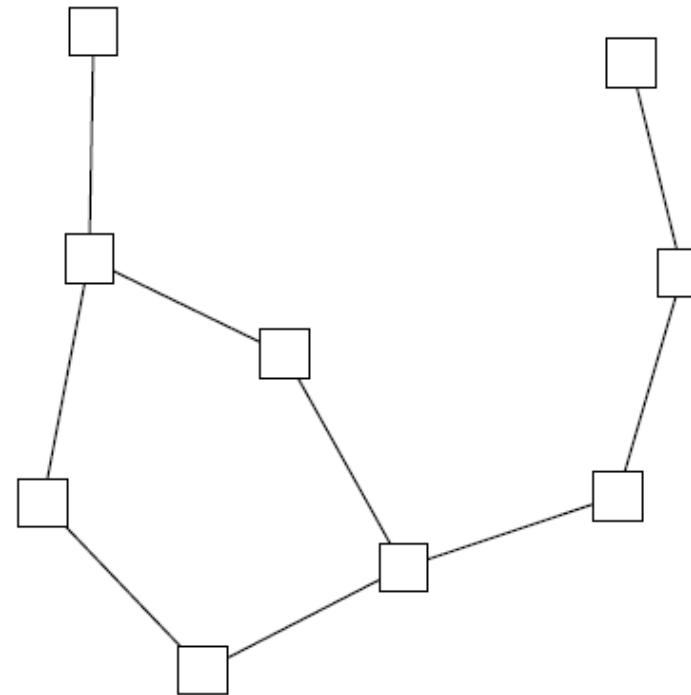
# GENERALIZED NETWORK PSYCHOMETRICS: COMBINING NETWORK AND LATENT VARIABLE MODELS

SACHA EPSKAMP, MIJKE RHEMTULLA & DENNY BORSBOOM

UNIVERSITY OF AMSTERDAM



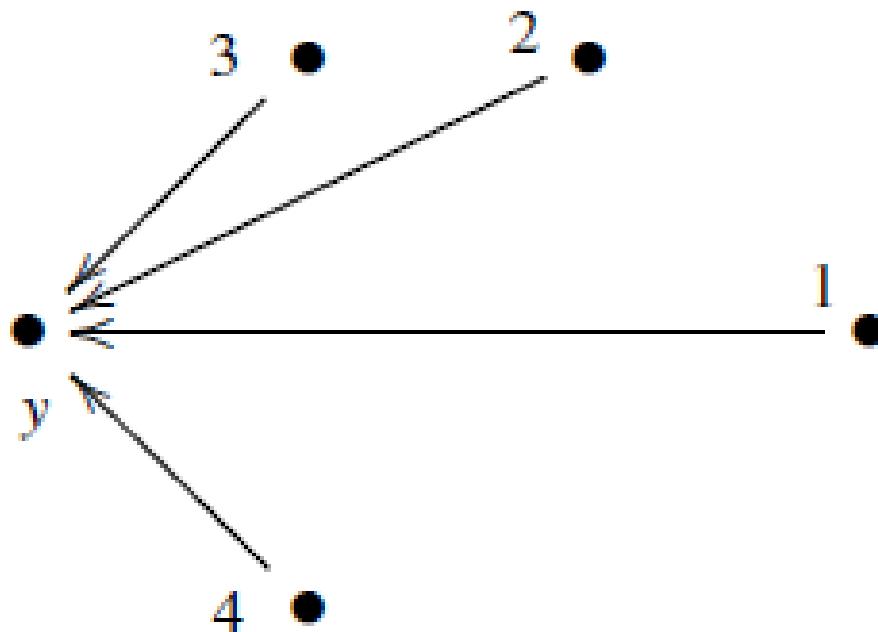
(a) Structural Equation Modeling



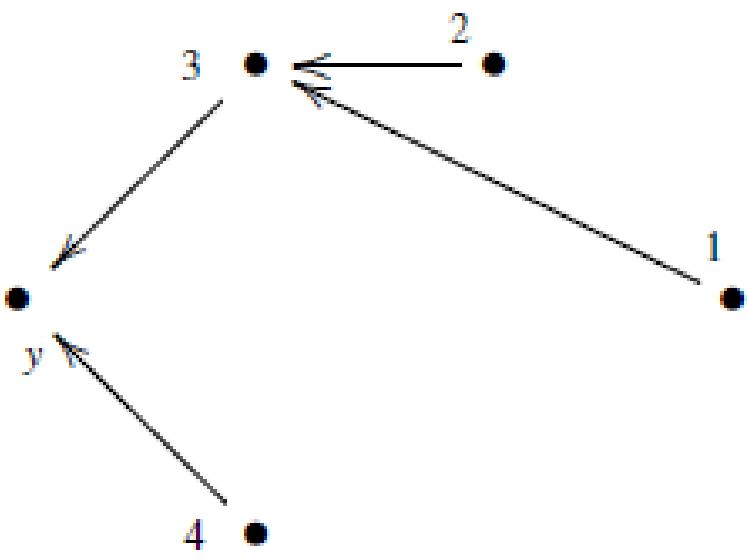
(b) Network Modeling

# Modelos preditivos

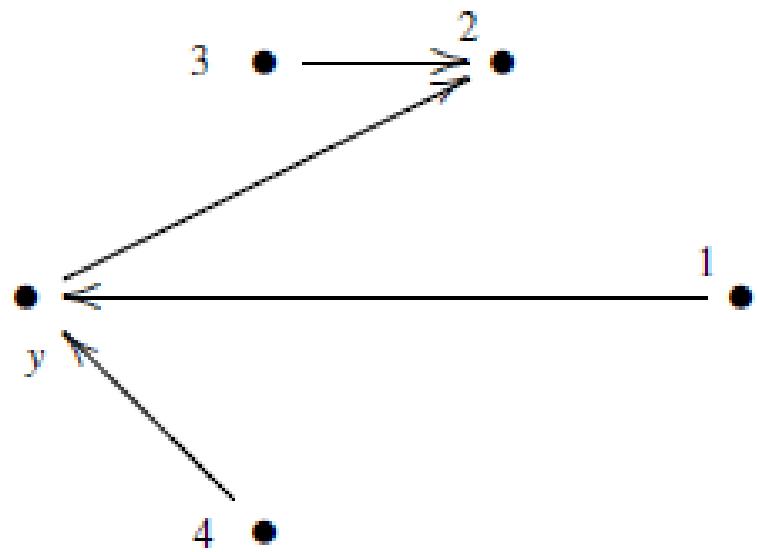
- Modelo de regressão comum



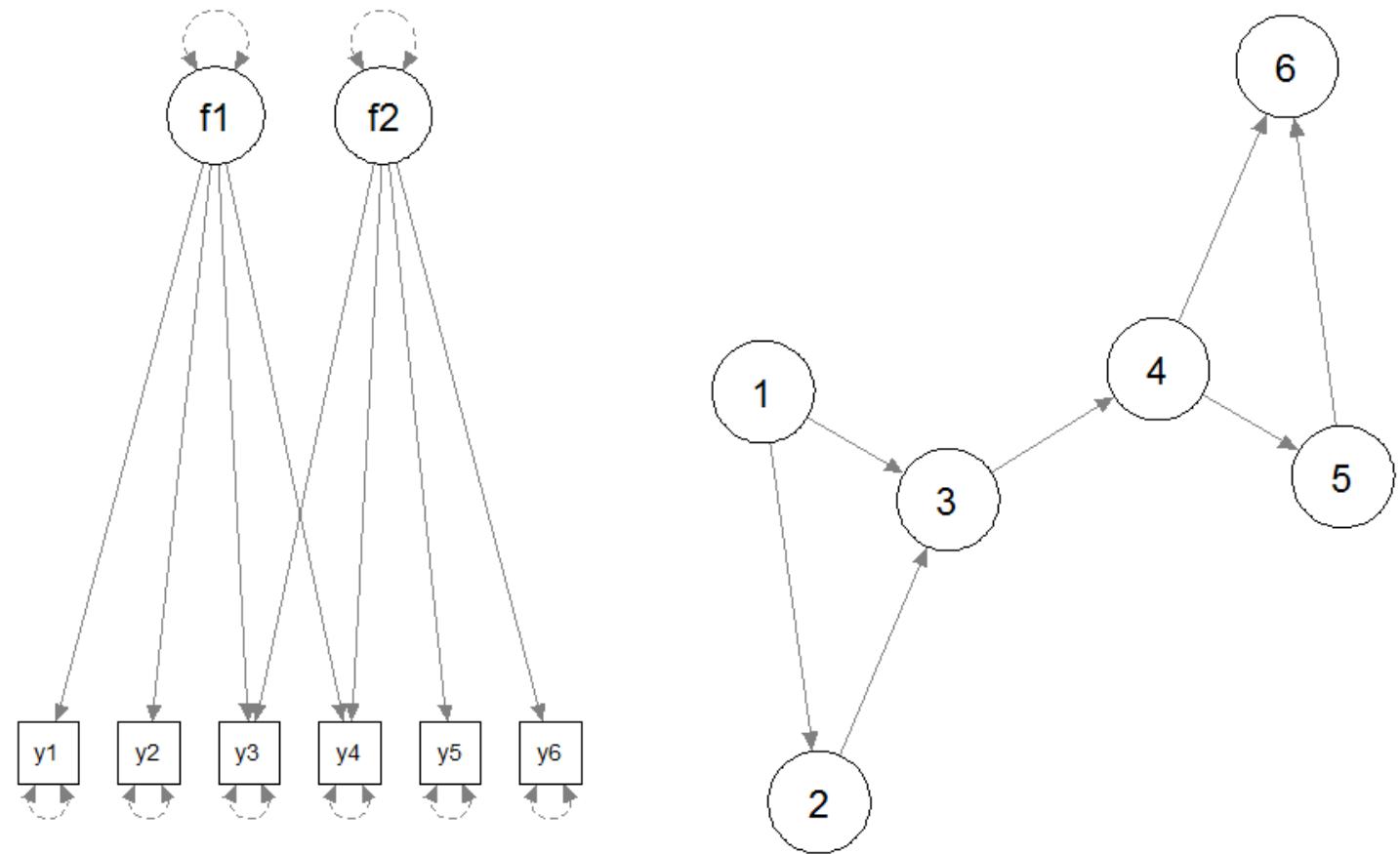
(Epskamp, 2013)



?



# Representação de dados psicométricos em rede



# Exemplos com dados de personalidade



---

*Journal of Statistical Software*

May 2012, Volume 48, Issue 4.

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

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## 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

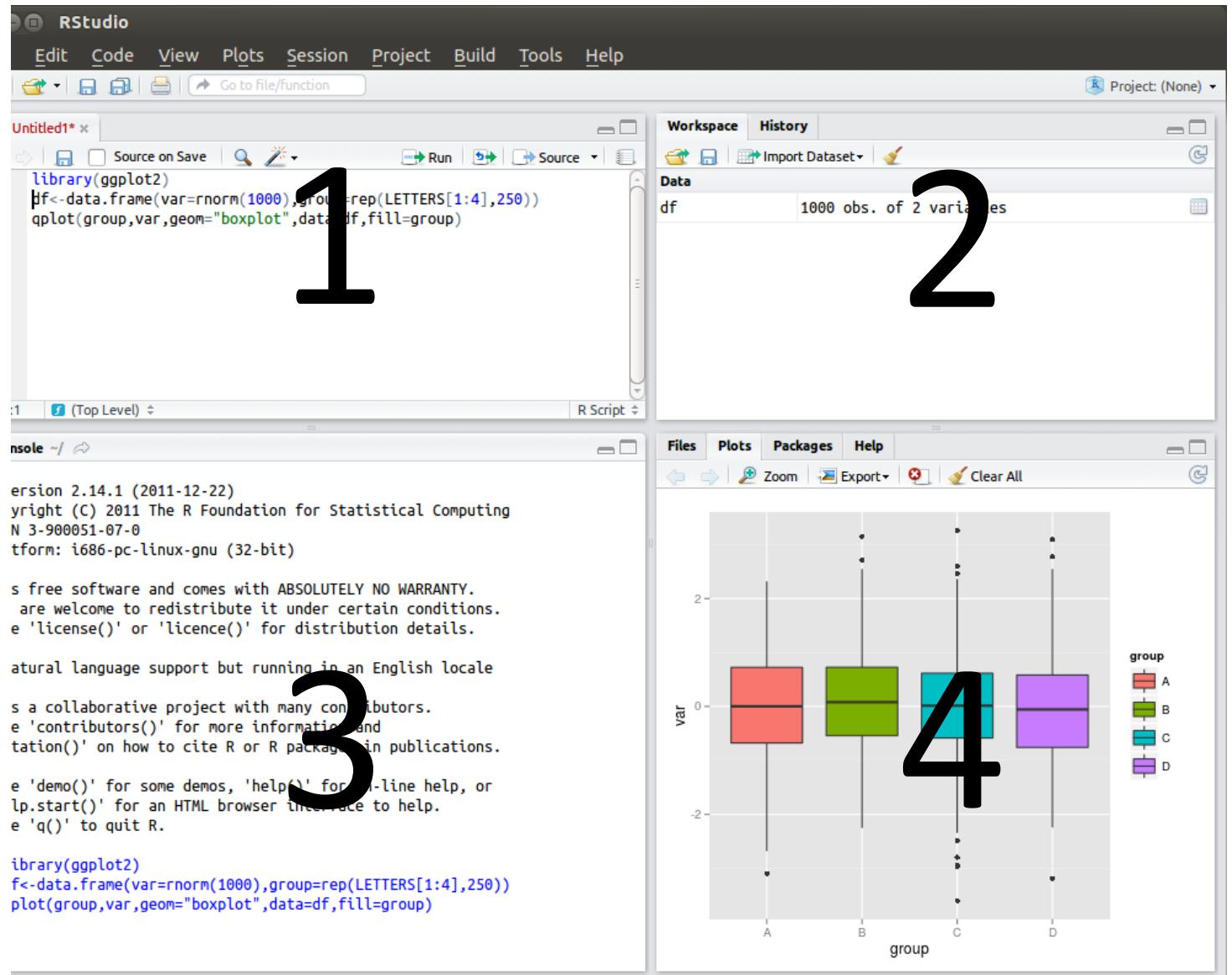
# RStudio

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

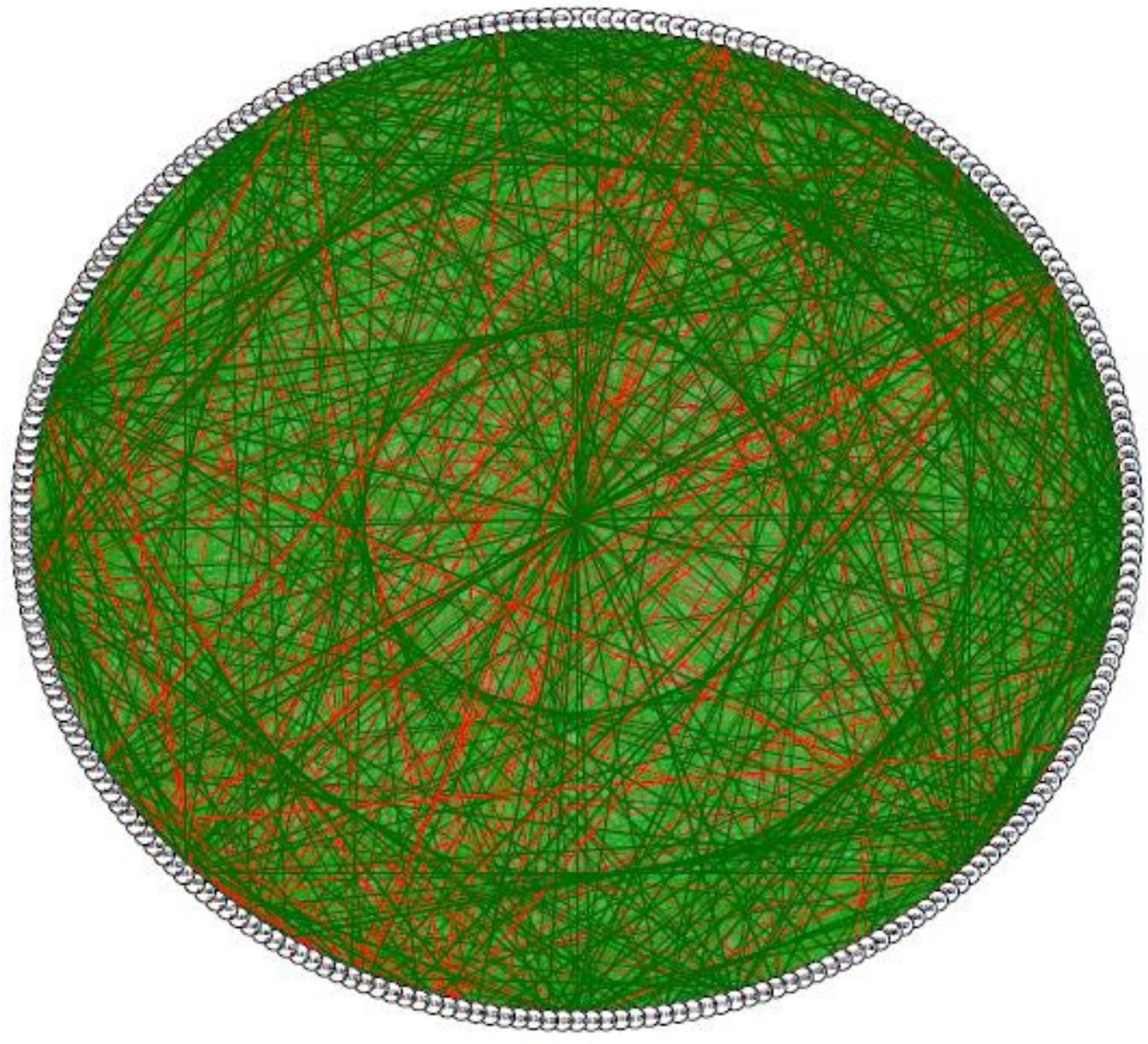
2 – repositório de objetos e funções

3 – log de atividade

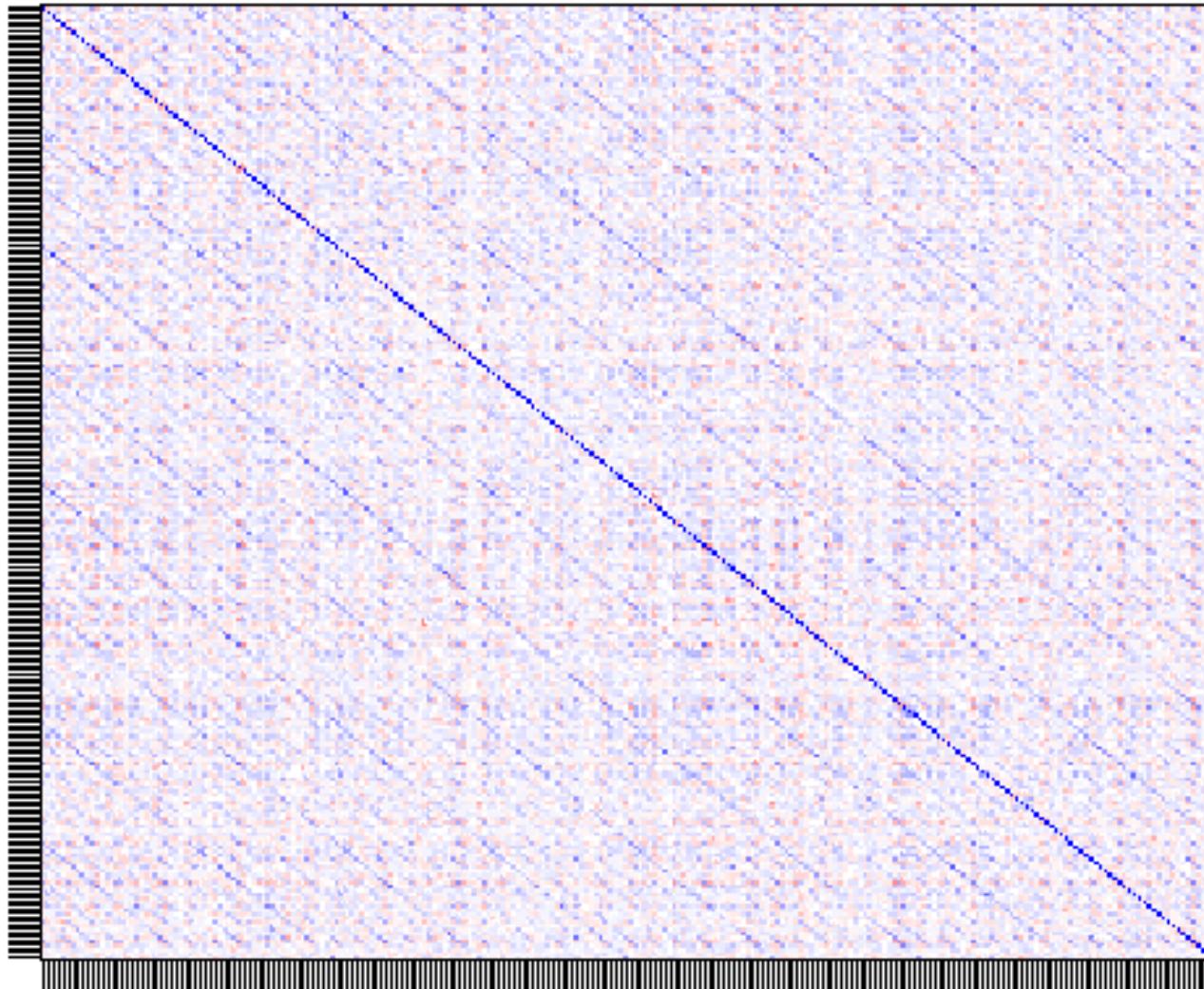
4 – gráficos e documentação



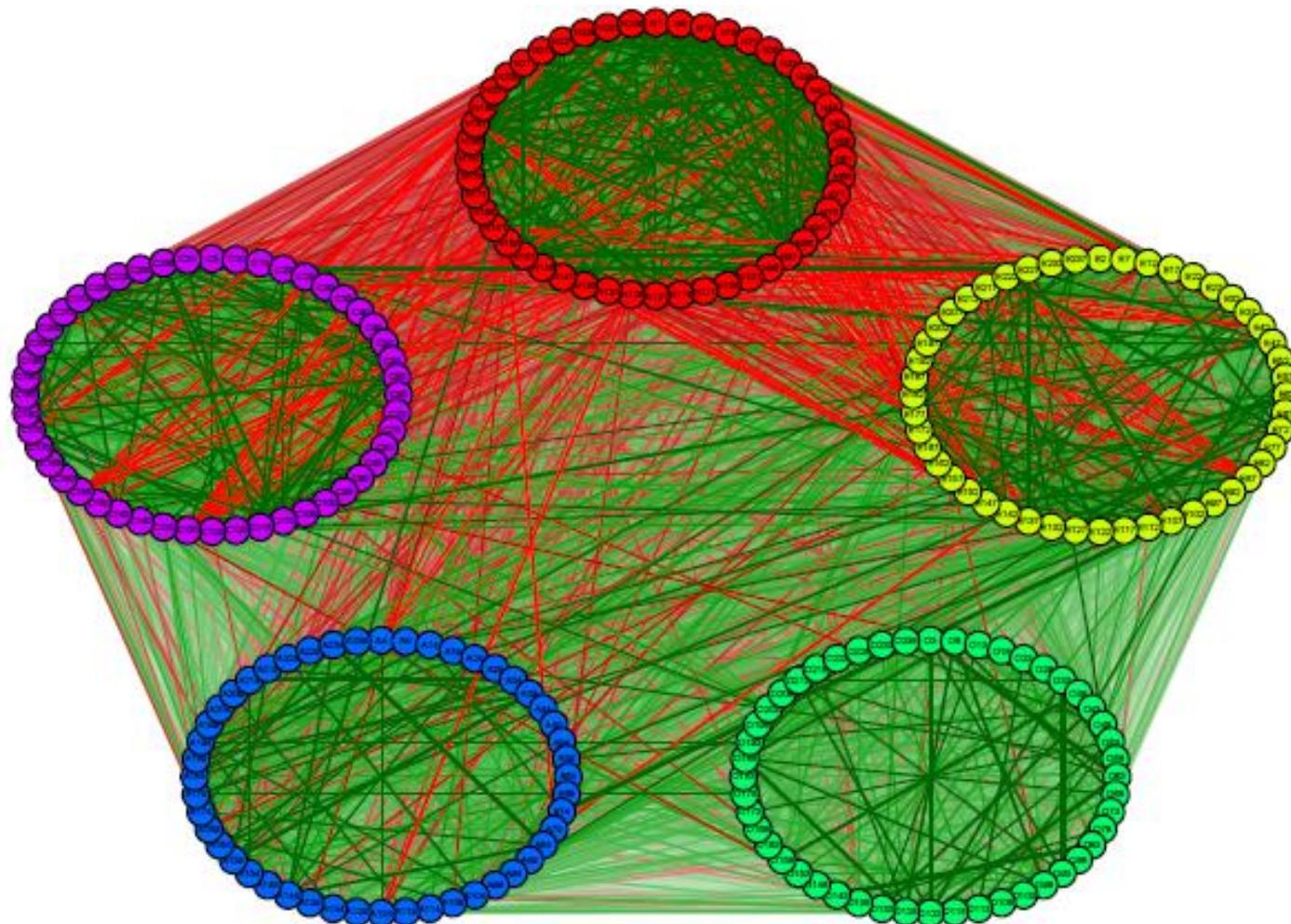
```
#preparação  
data("big5")  
View(big5)  
qgraph(cor(big5))  
data("big5groups")
```



cor.plot(cor(big5))

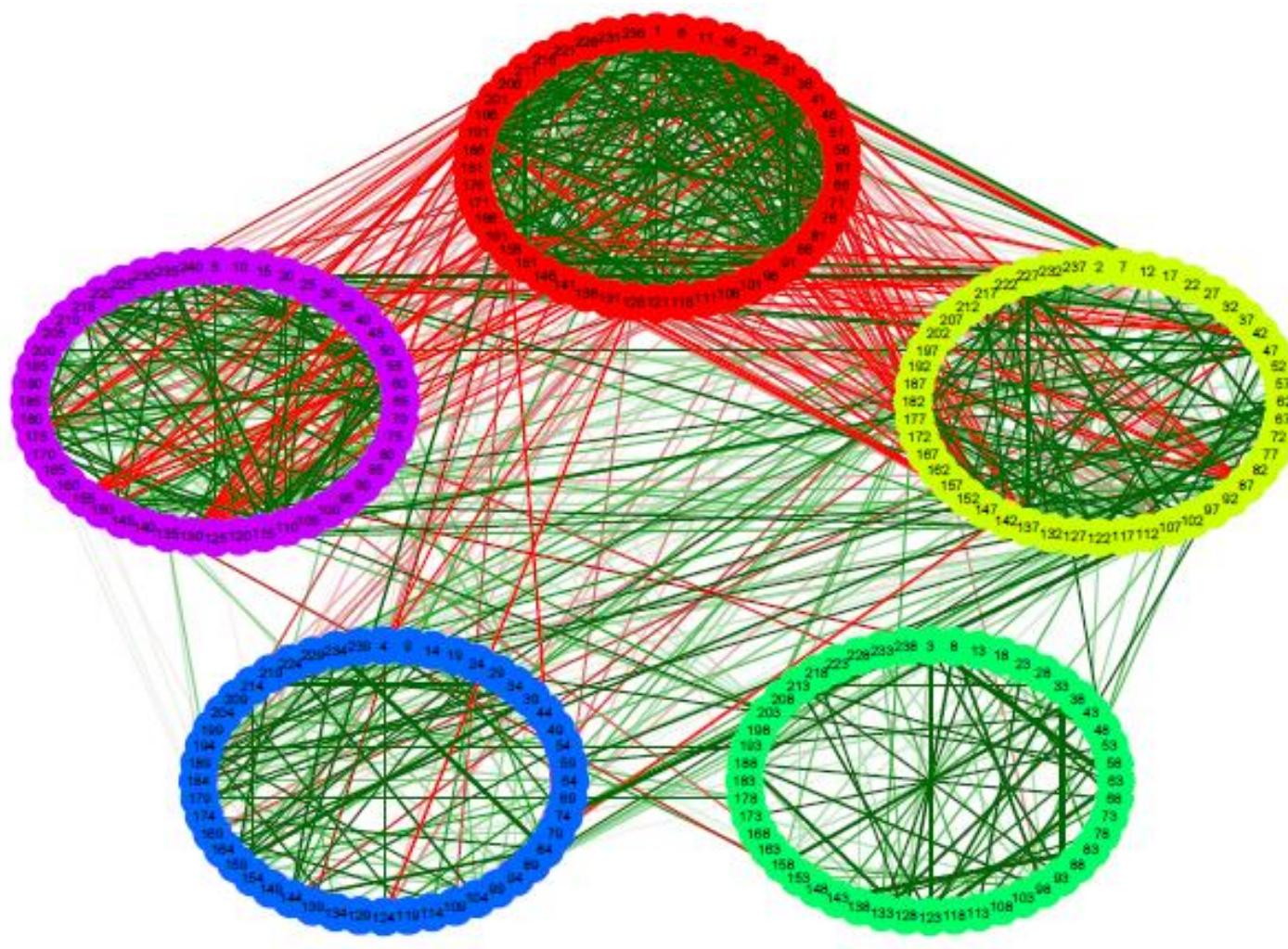


```
Q<-qgraph(cor(big5),groups=big5groups)
```



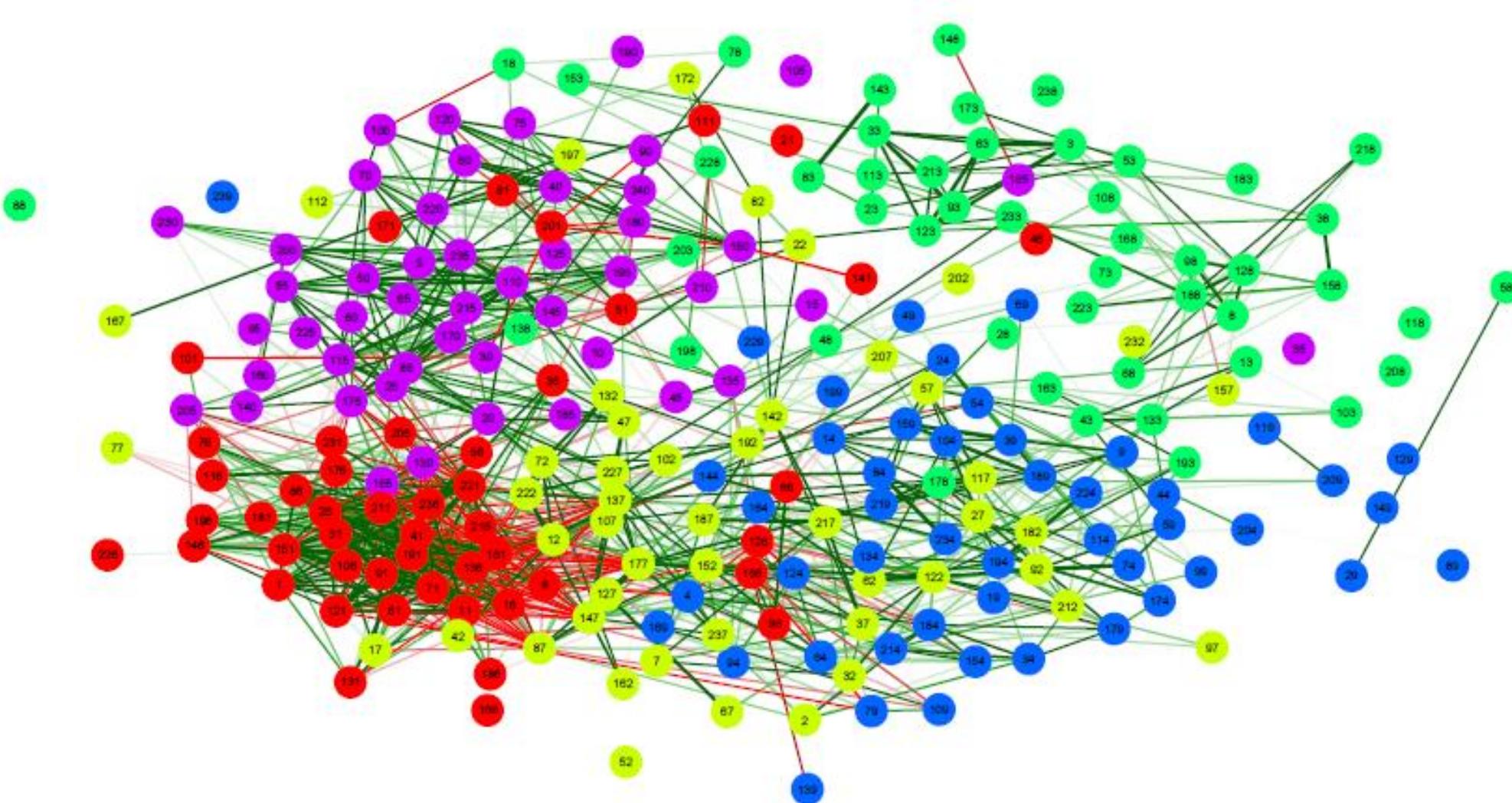
- Neuroticism
- Extraversion
- Openness
- Agreeableness
- Conscientiousness

```
Q<-qgraph(Q,minimum=0.25,borders=F,vsize=2)
```



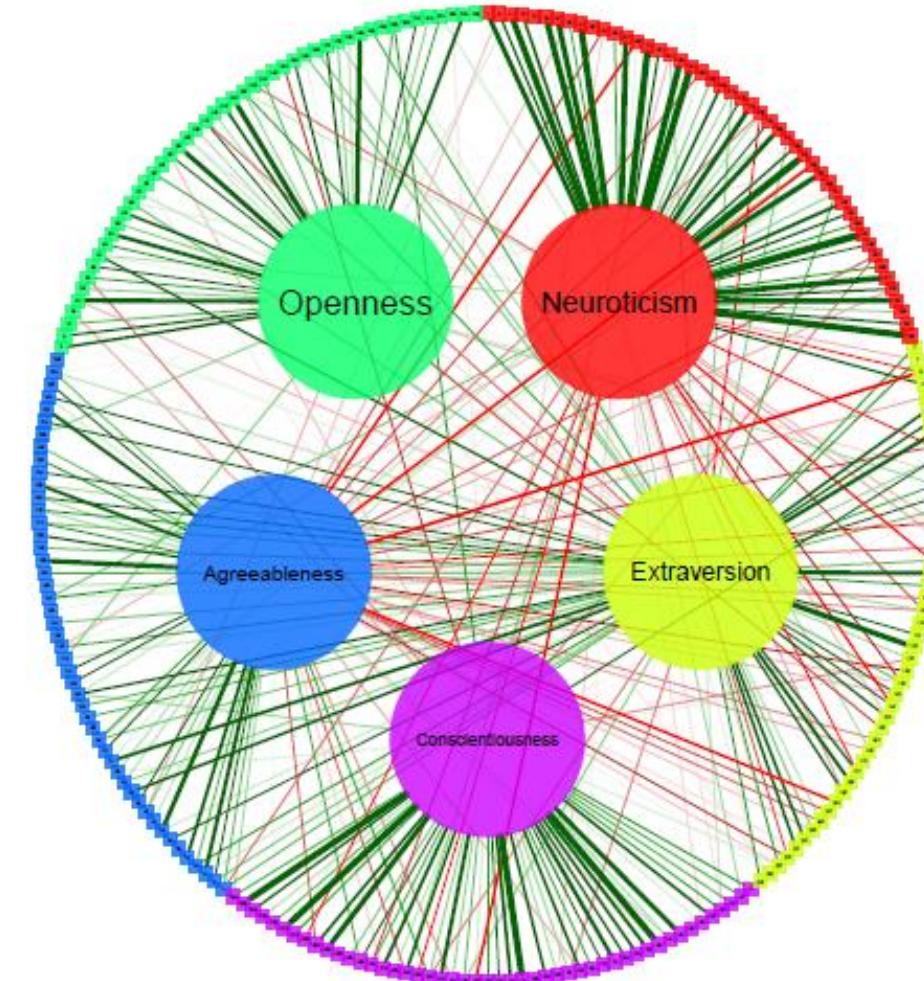
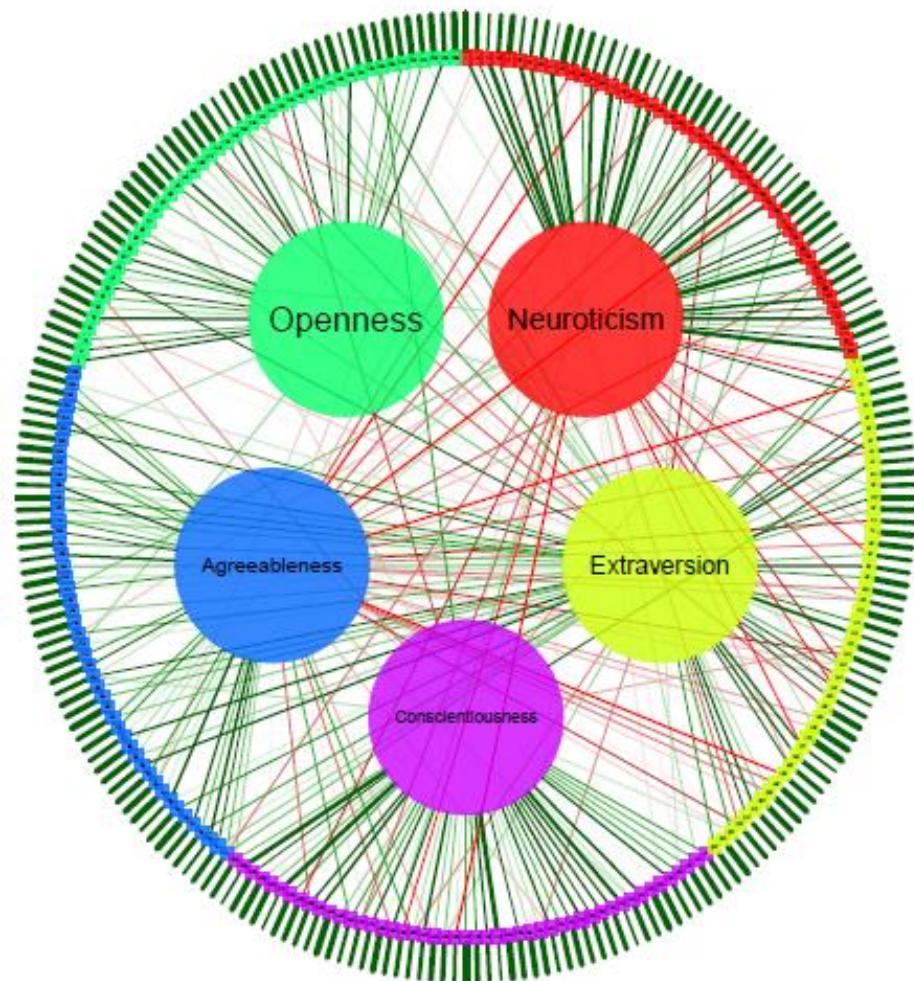
- Neuroticism
- Extraversion
- Openness
- Agreeableness
- Conscientiousness

qgraph(Q,layout="spring",legend=F)

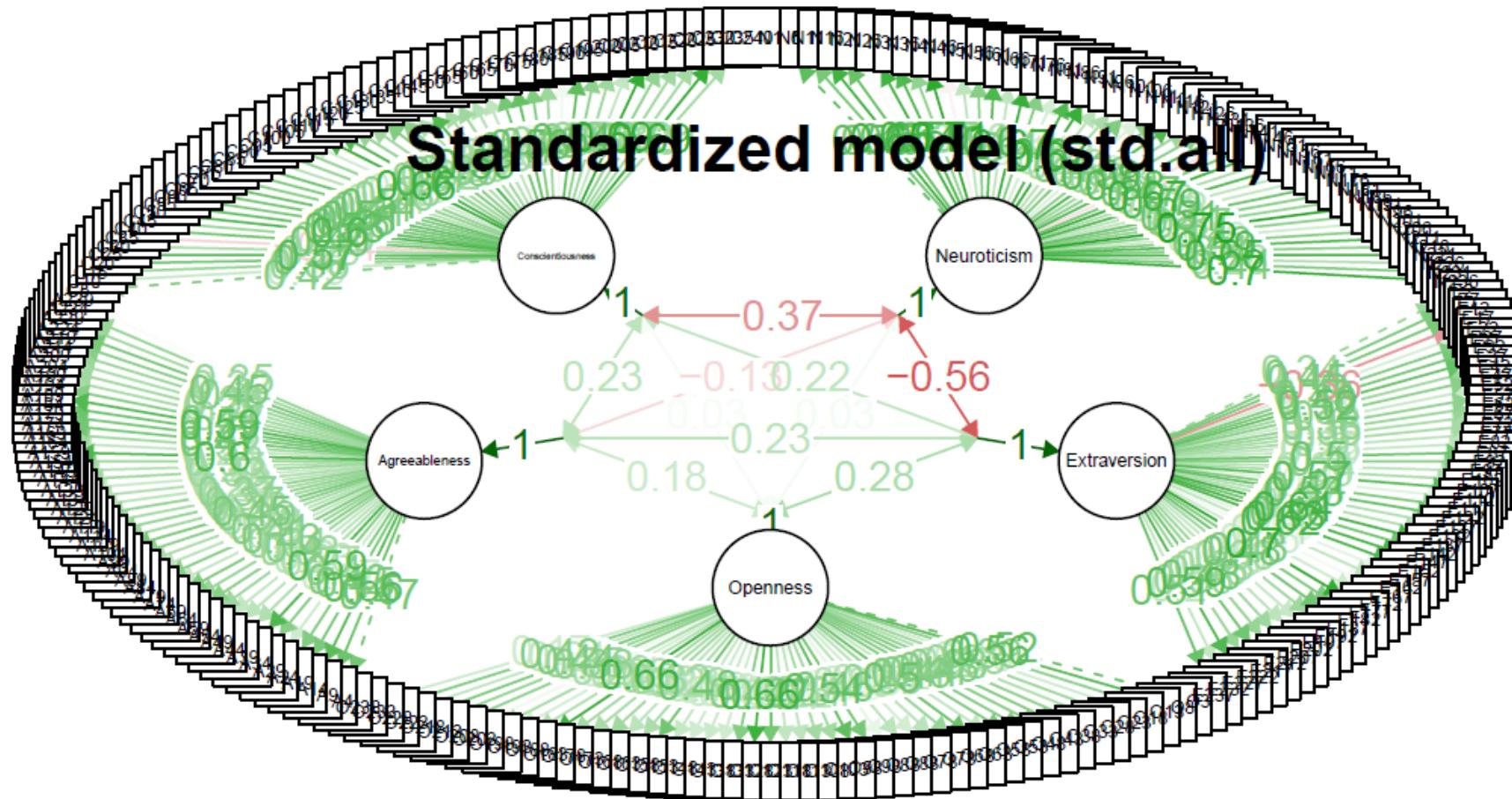


AFE, componentes principais e AFC

```
qgraph.efa(big5,5,groups=big5groups,rotation="promax",minimum=0.2,cut=0.4,vsize=c(1,15),borders=F,asize=0.07,esize=4,vTrans=200)  
qgraph.pca(big5,5,groups=big5groups,rotation="promax",minimum=0.2,cut=0.4,vsize=c(1,15),borders=F,asize=0.07,esize=4,vTrans=200)
```



```
big5_fit<-qgraph.cfa(cov(big5), N = nrow(big5), groups = big5groups,pkg="lavaan",opts=list(se="none"),fun=print)  
qgraph(big5_fit)
```



# Redes gaussianas

A Tutorial on Regularized Partial Correlation Networks

Sacha Epskamp and Eiko I. Fried

University of Amsterdam: Department of Psychological Methods

**Regularized Gaussian Psychological Networks: Brief Report on the Performance of Extended BIC Model Selection**

Sacha Epskamp

University of Amsterdam: Department of Psychological Methods

In recent literature, the Gaussian Graphical model (GGM; Lauritzen, 1996), a network of partial correlation coefficients, has been used to capture potential dynamic relationships between psychological variables. The GGM can be estimated using regularization in combination with model selection using the extended Bayesian Information Criterion (Foygel and Drton, 2010). I term this methodology *GeLasso*, and asses its performance using a plausible psychological network structure with both continuous and ordinal datasets. Simulation results indicate that GeLasso works well as an out-of-the-box method to estimate a psychological network structure.

n 2016

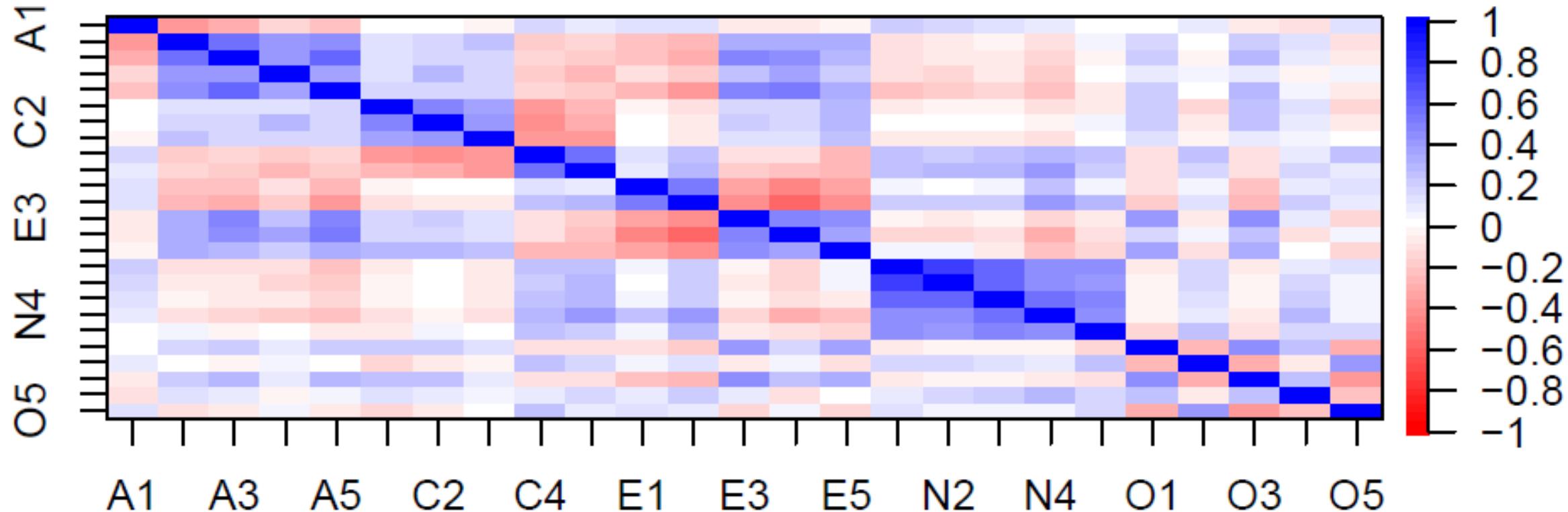
Recent years have seen a emergence of the network conceptualisation of psychology, in which relationships between

of networks is estimated under different values of  $\lambda$  (Zhao & Yu, 2006). The value for  $\lambda$  under which no edges are retained

# Preparação

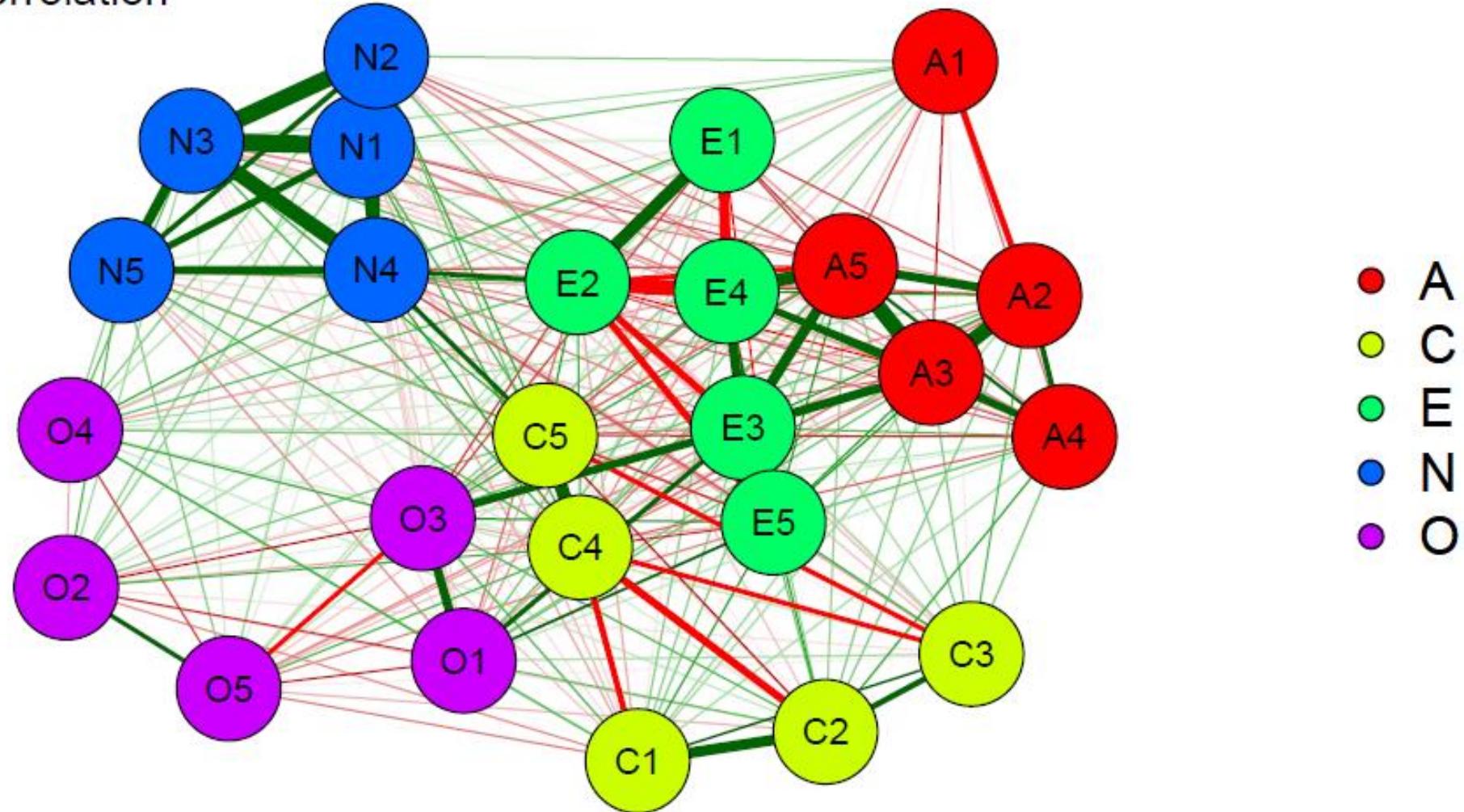
```
#exemplo BFI (banco do pacote psych)
bfi2<-getURL("https://raw.githubusercontent.com/wagnerLM/networkIBAP/master/bfi.csv")
bfi2<-read.csv(text = bfi2,sep=";")
View(bfi2)
#nomes e agrupamentos das variáveis
bfi2_names<-list("Am indifferent to the feelings of others","Inquire about others' well-being","Know how to comfort others","Love children","Make people feel at ease","Am exacting in my work","Continue until everything is perfect","Do things according to a plan","Do things in a half-way manner","Waste my time","Don't talk a lot","Find it difficult to approach others","Know how to captivate people","Make friends easily","Take charge","Get angry easily","Get irritated easily","Have frequent mood swings","Often feel blue","Panic easily","Am full of ideas","Avoid difficult reading material","Carry the conversation to a higher level","Spend time reflecting on things","Will not probe deeply into a subject","Gender(1=M,2=F)","education","age(years)")
bfi2_groups<-rep(c("A","C","E","N","O"),each=5)
#gerando a matriz de correlações
bfi2_cors<-cor_auto(bfi2[1:25])
#visualizando a matriz de correlações
cor.plot(bfi2_cors)
```

## Correlation plot



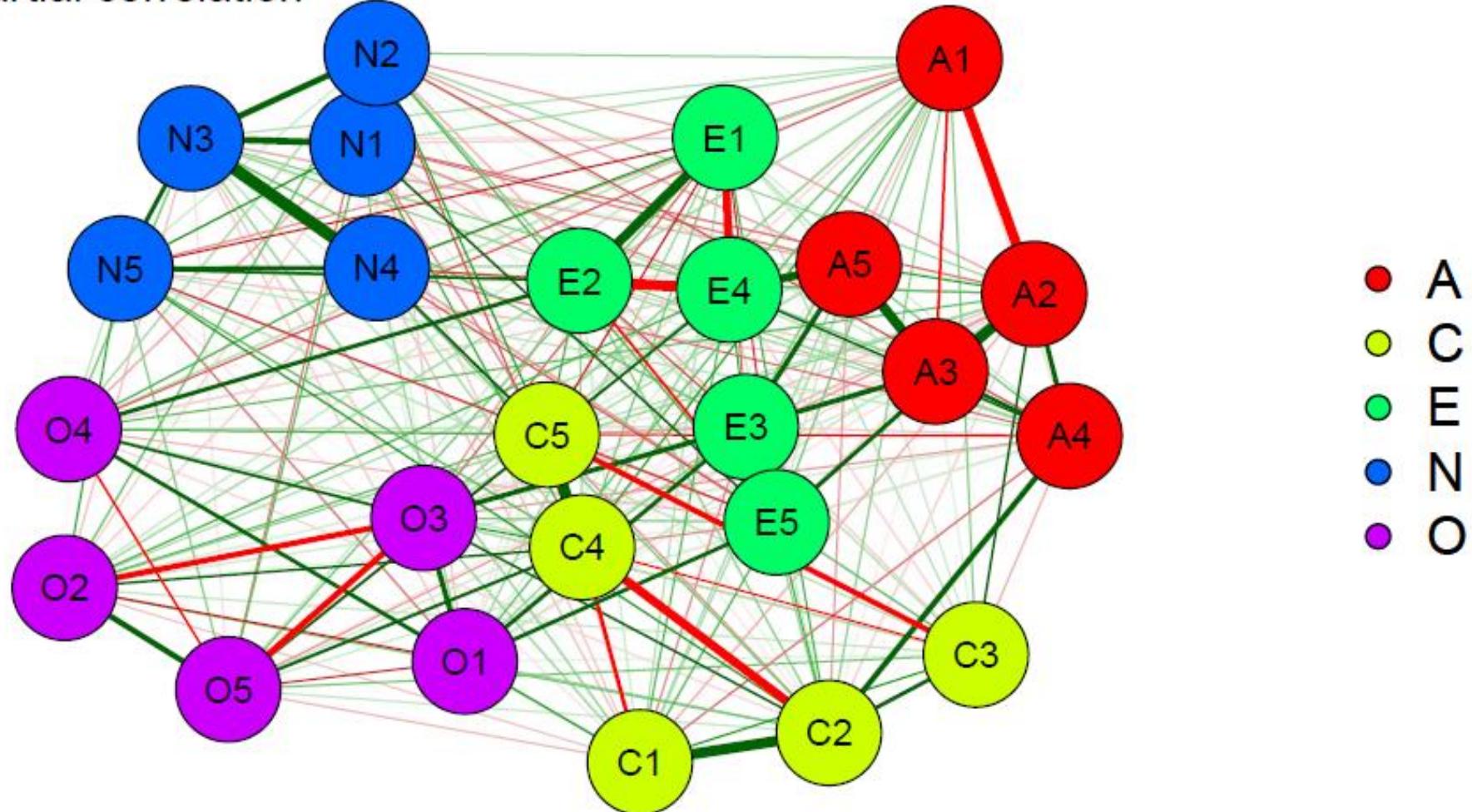
```
bfi2_corG<-qgraph(bfi2_cors,layout="spring",groups=bfi2_groups,title="correlation")
```

correlation



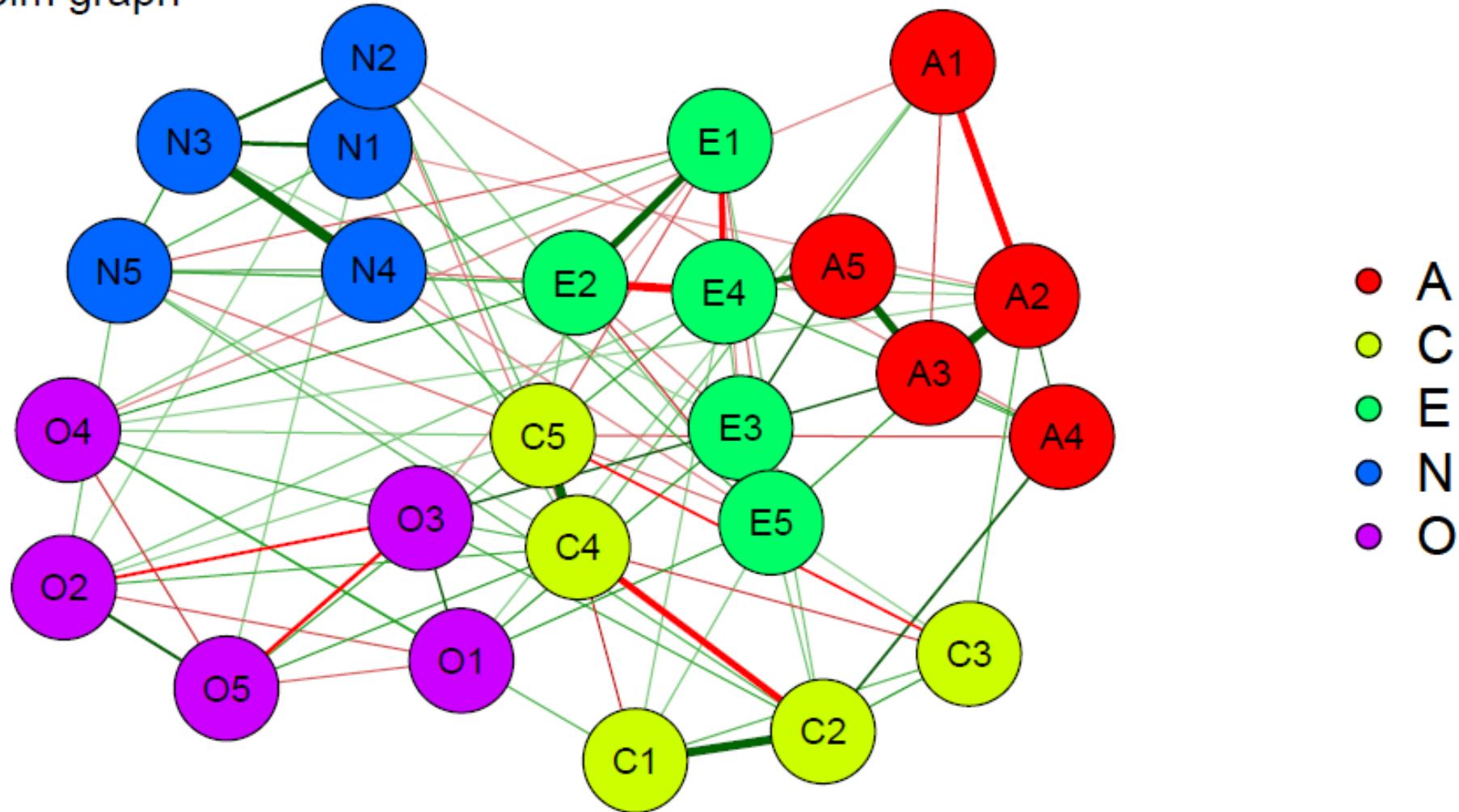
```
bfi2_pcorG<-qgraph(bfi2 Cors,layout=bfi2_corG$layout,groups=bfi2_groups,graph="pcor",title="partial correlation")
```

partial correlation



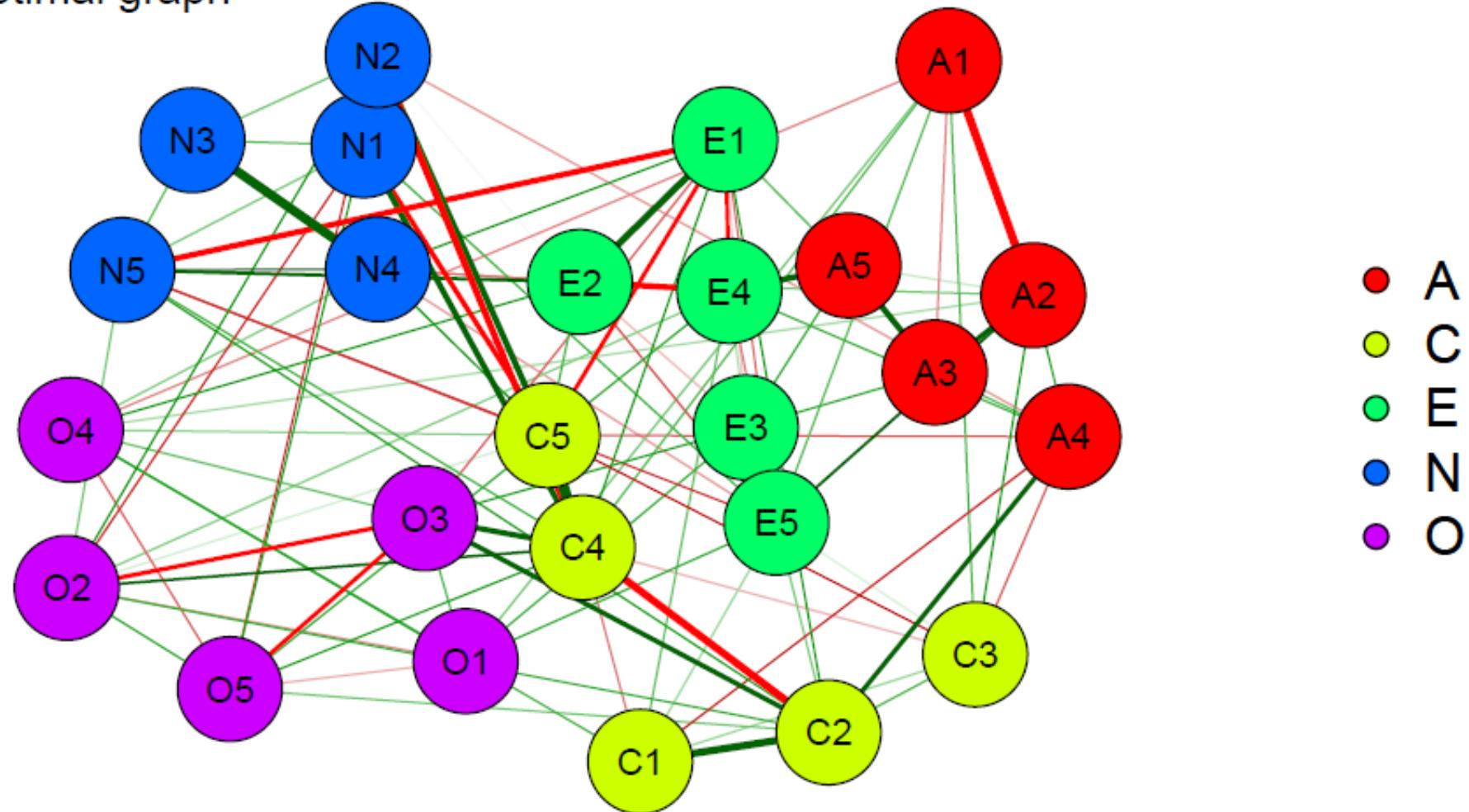
```
bfi2_holmG<-qgraph(bfi2_cors,layout=bfi2_corG$layout,groups=bfi2_groups,graph="pcor",threshold="holm",sampleSize=nrow(bfi),title="holm graph")
```

holm graph

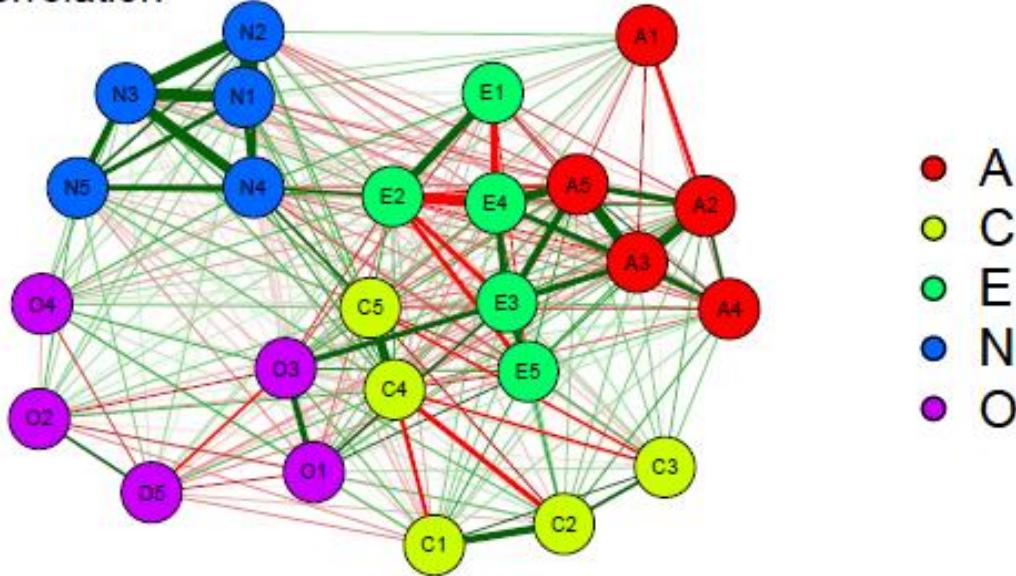


```
bfi2_optmG<-findGraph(bfi2_cors,nrow(bfi),type="pcor")
bfi2_optimalG<-qgraph(bfi2_optmG,layout=bfi2_corG$layout,groups=bfi2_groups,labels=colnames(bfi2_cors),title="optimal graph")
```

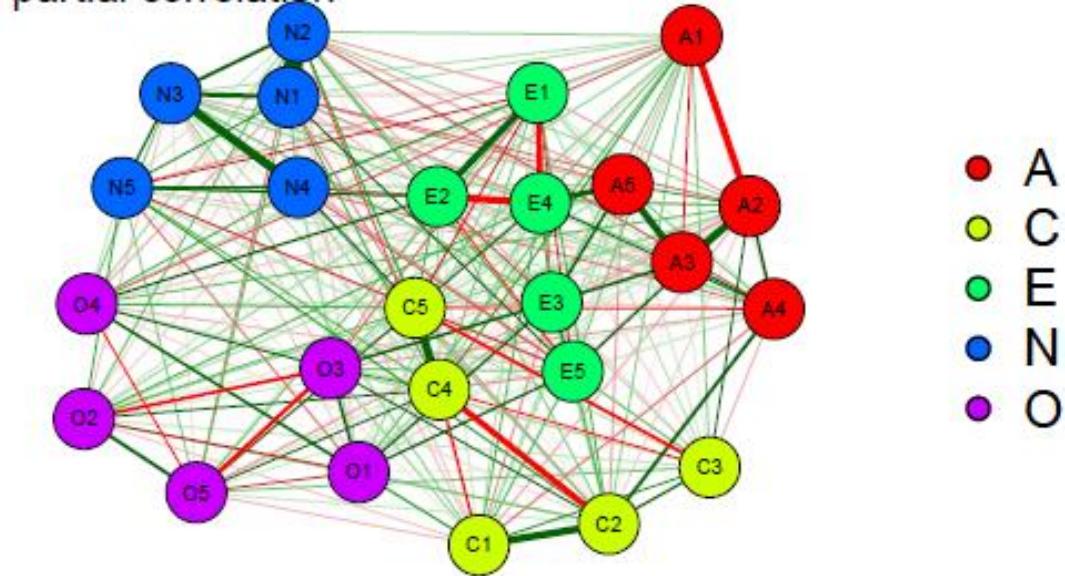
optimal graph



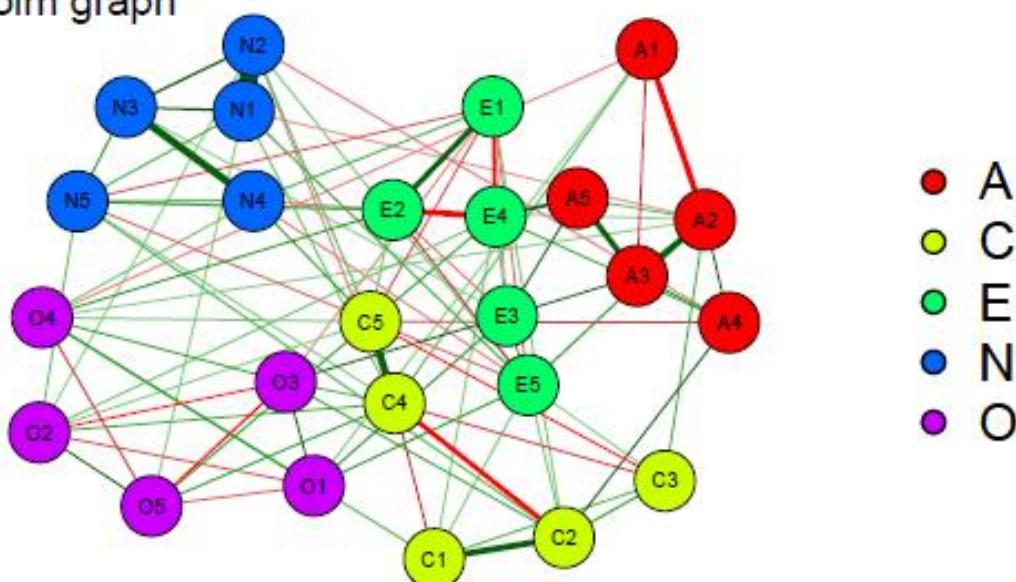
correlation



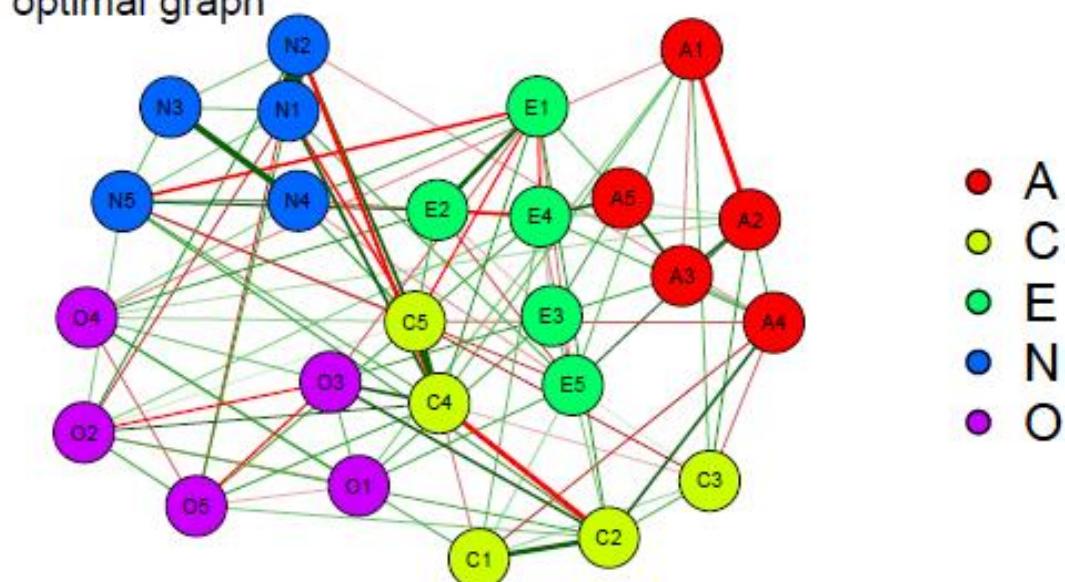
partial correlation



holm graph

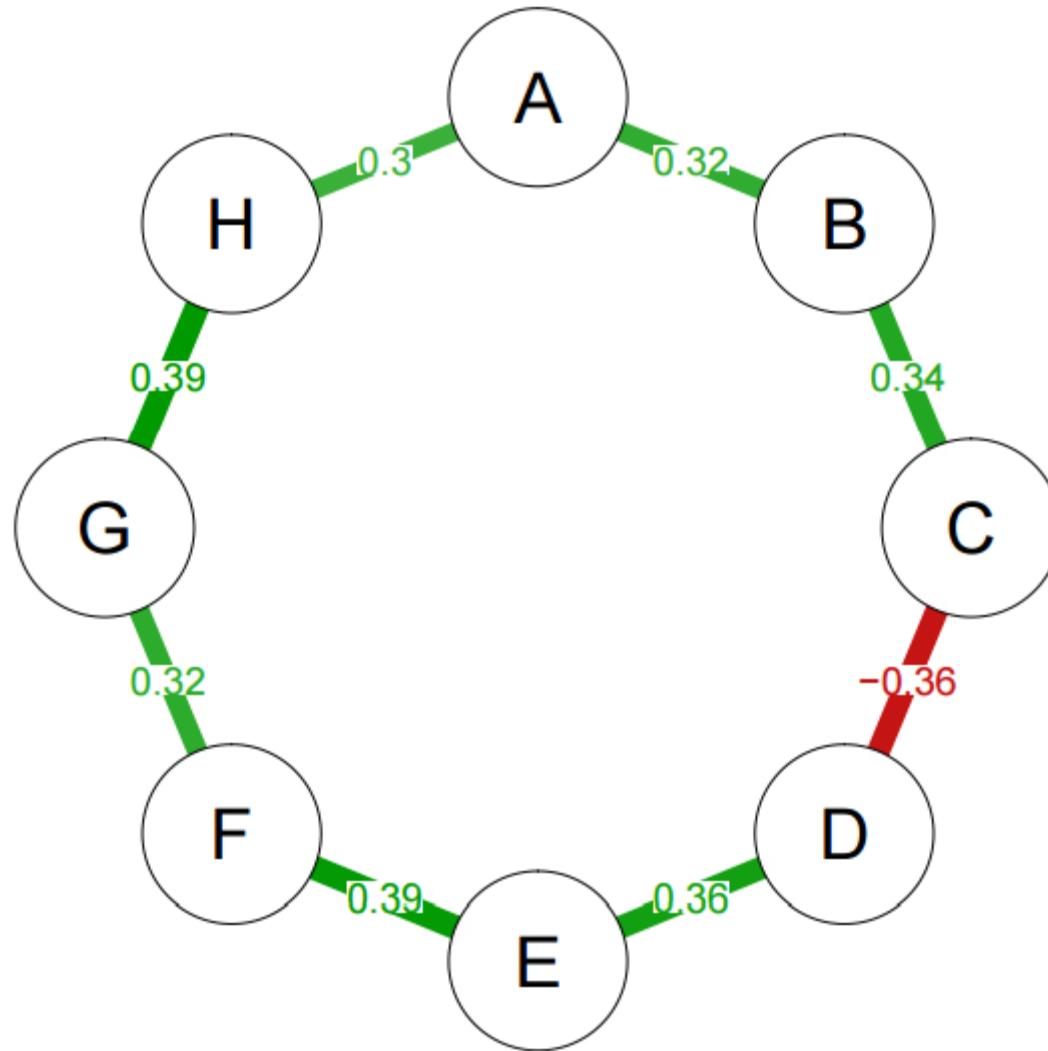


optimal graph

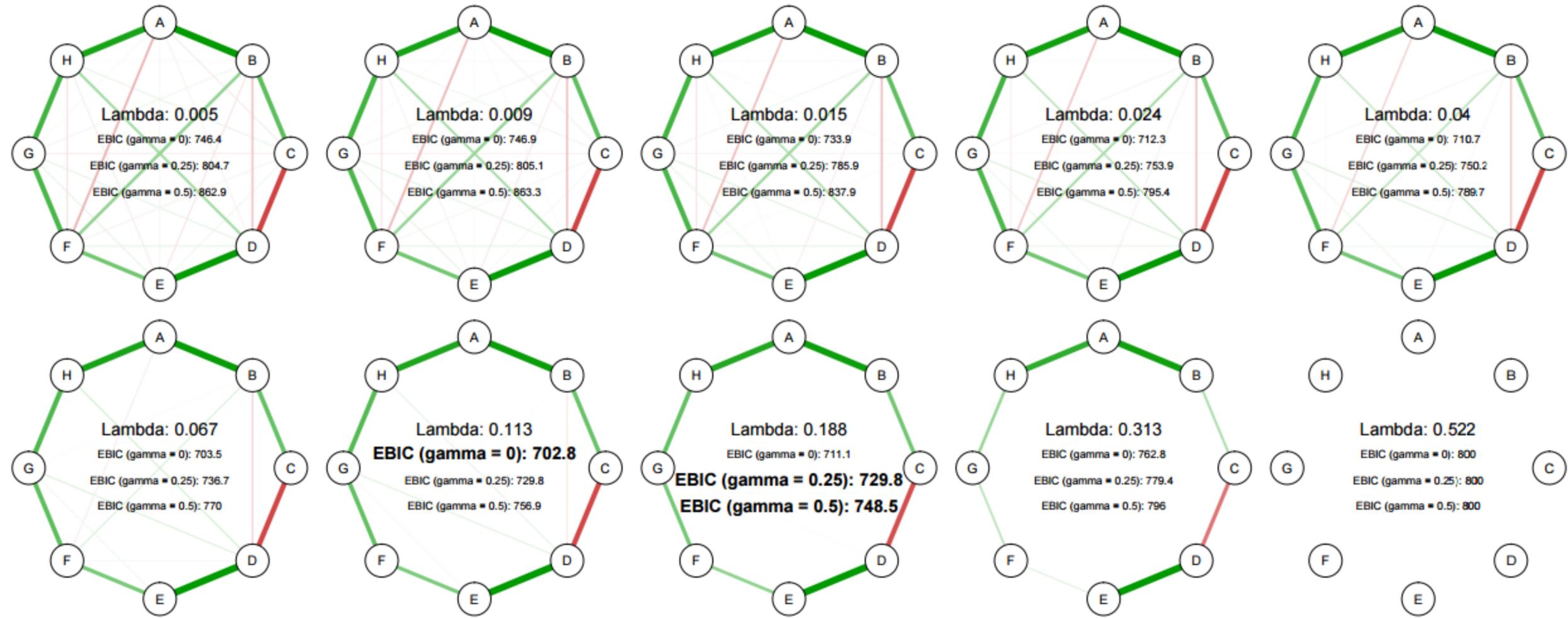


# GeLasso estimation

- 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  $\lambda$
- São testados, por default, 100 valores de  $\lambda$
- A seleção do modelo com menor resíduo é feita por meio do Extended Bayesian Criteria (EBIC), que penaliza modelos complexos (muitas arestas), chamado hiperparâmetro  $\gamma$ . Se  $\gamma = 0$ , o método é o BIC.
- Correlação parcial – regressões múltiplas “nodewise”



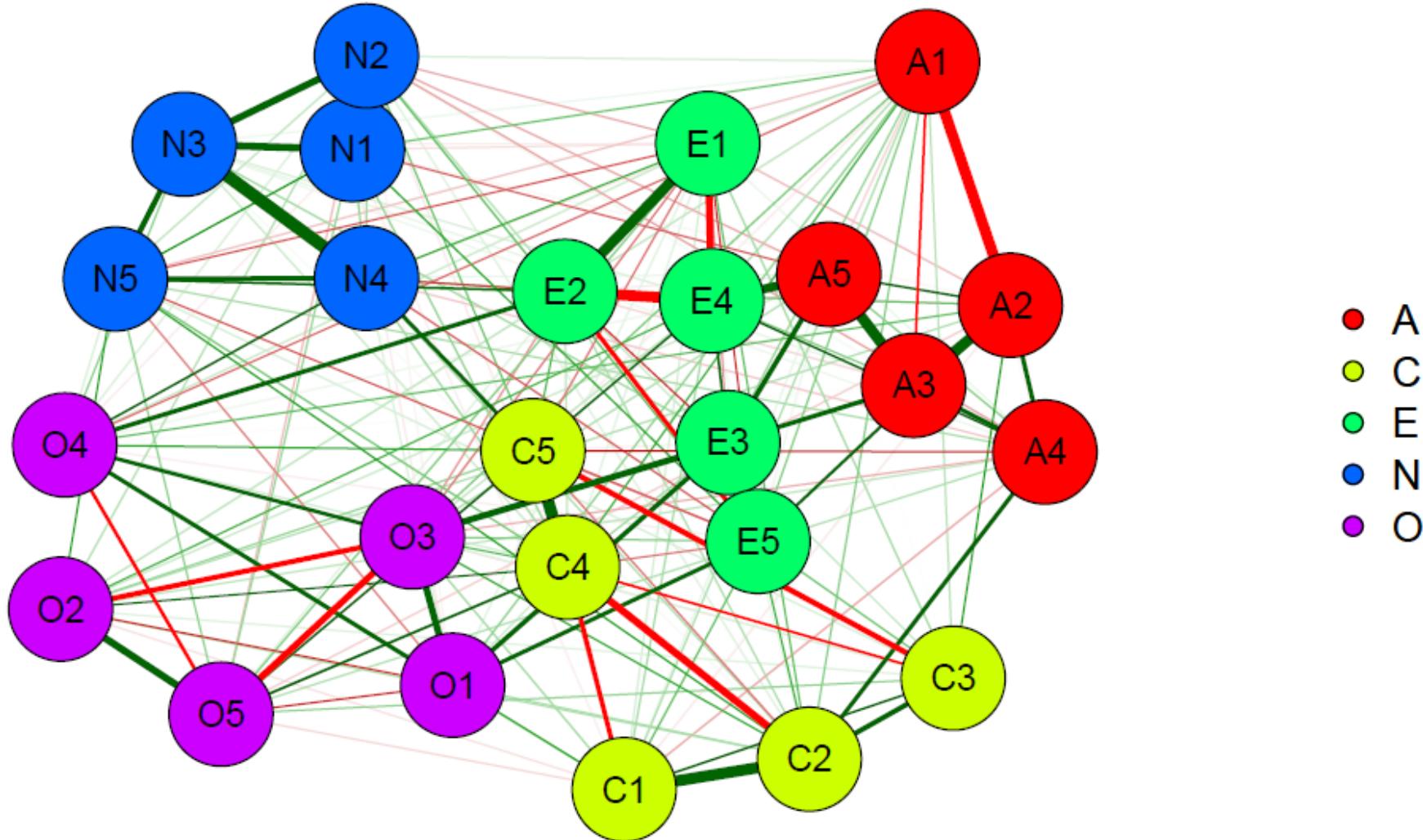
(Epskamp & Fried, 2006)



(Epskamp & Fried, 2006)

```
bfi2_glassoG<-qgraph(bfi2 Cors,layout=bfi2_CorG$layout,groups=bfi2_Groups,graph="glasso",sampleSize=nrow(bfi),tuning=0.25,title="GeLasso")
```

GeLasso



# Índices de ajuste, semelhante à SEM

```
bfi2_cov<-cov(bfi2,use = "pairwise.complete.obs")
bfi2_fit<-ggmFit(bfi2_glassoG,bfi2_cov,nrow(bfi2))
bfi2_fit$fitMeasures
```

Chi-squared = 92

DF = 118

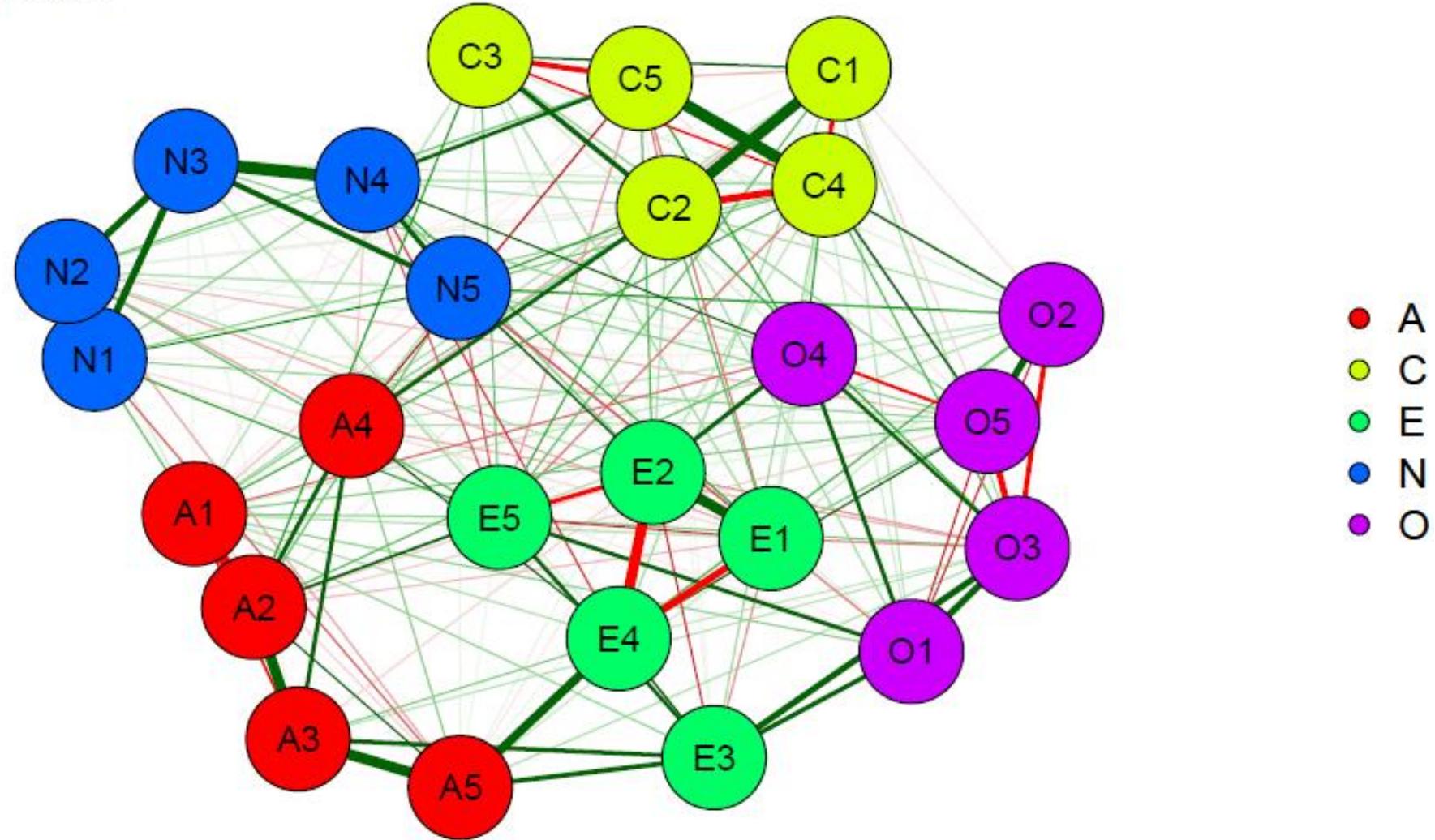
p = 0,96

TLI = 1

RMSEA = 0

```
bfi2_glassoG<-qgraph(bfi2 Cors,layout="spring",groups=bfi2 Groups,graph="glasso",sampleSize=nrow(bfi),tuning=0.25,title="GeLasso")
```

GeLasso

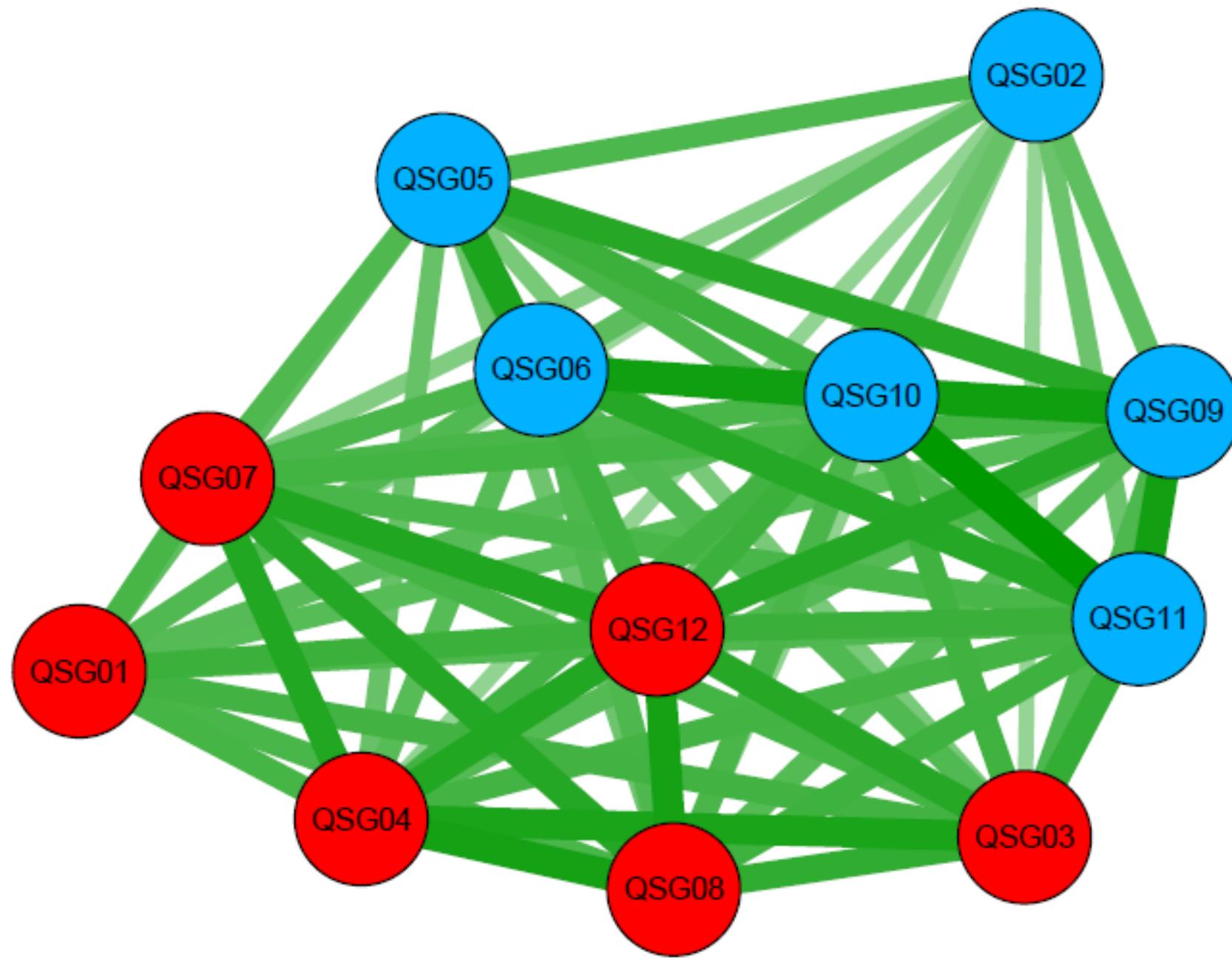


# Redes gaussianas

- É possível fazer uma aproximação não paramétrica de variáveis gaussianas (cor\_auto)
- Por exemplo, nas correlações tetra e polycóricas se assume que as variáveis latentes são gaussianas e suas realizações amostrais são categóricas

# Questionário de Saúde Geral (Goldberg)

- Incerteza na literatura sobre sua estrutura fatorial (1 ou 2 fatores)

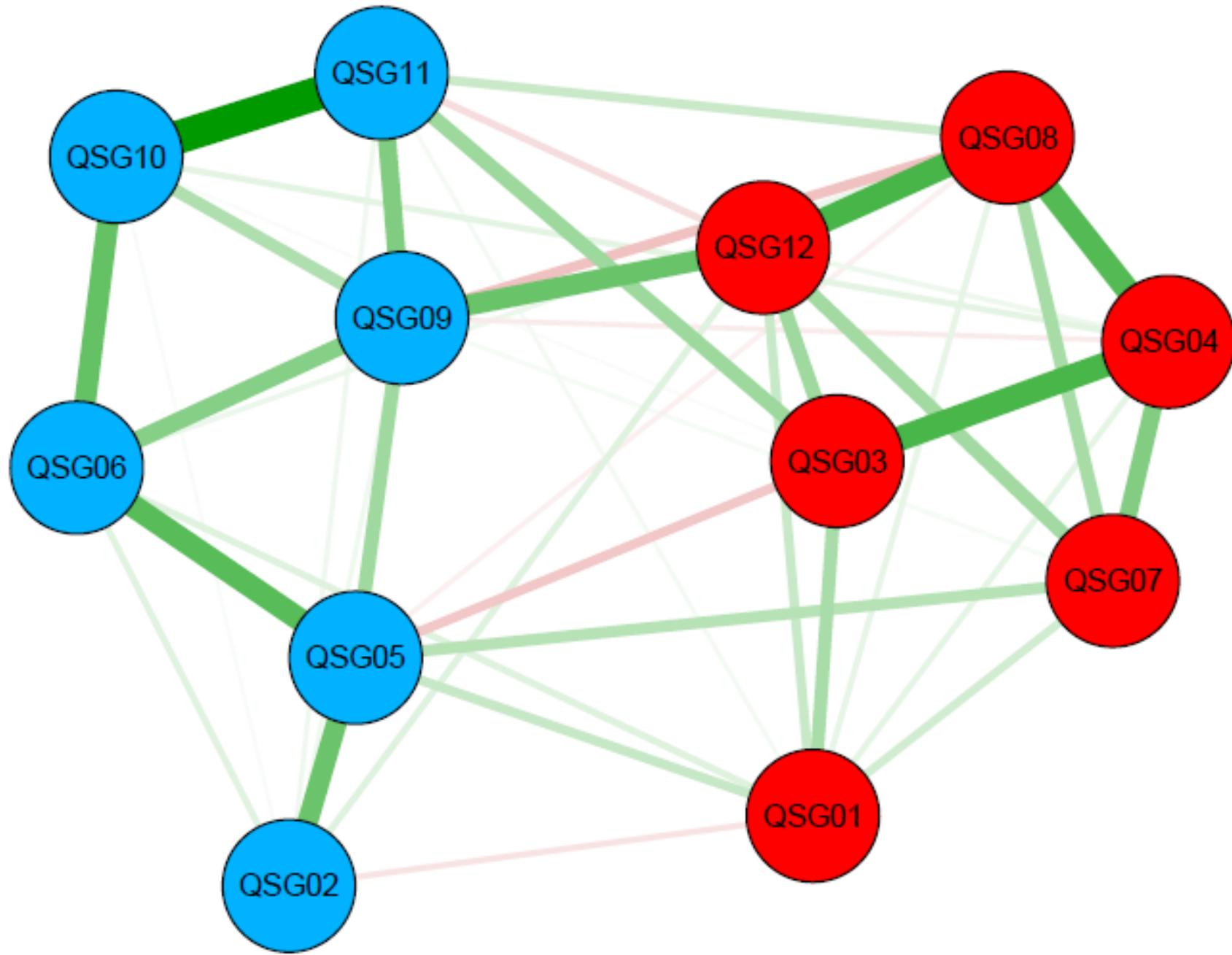


#### positivos

- QSG01: Tem podido concentrar-se no que faz
- QSG03: Tem sentido que tem papel útil na vida
- QSG04: Tem sido capaz de tomar decisões
- QSG07: Tem sido capaz de desfrutar de atividades
- QSG08: Tem sido capaz de enfrentar problemas
- QSG12: Sente-se razoavelmente feliz

#### negativos

- QSG02: Suas preocupações o fazem perder o sono
- QSG05: Tem notado que está agoniado
- QSG06: Tem sensação de não superar dificuldades
- QSG09: Tem se sentido pouco feliz e deprimido
- QSG10: Tem perdido confiança em si mesmo
- QSG11: Tem pensado que não serve para nada



#### positivos

- QSG01: Tem podido concentrar-se no que faz
- QSG03: Tem sentido que tem papel útil na vida
- QSG04: Tem sido capaz de tomar decisões
- QSG07: Tem sido capaz de desfrutar de atividades
- QSG08: Tem sido capaz de enfrentar problemas
- QSG12: Sente-se razoavelmente feliz

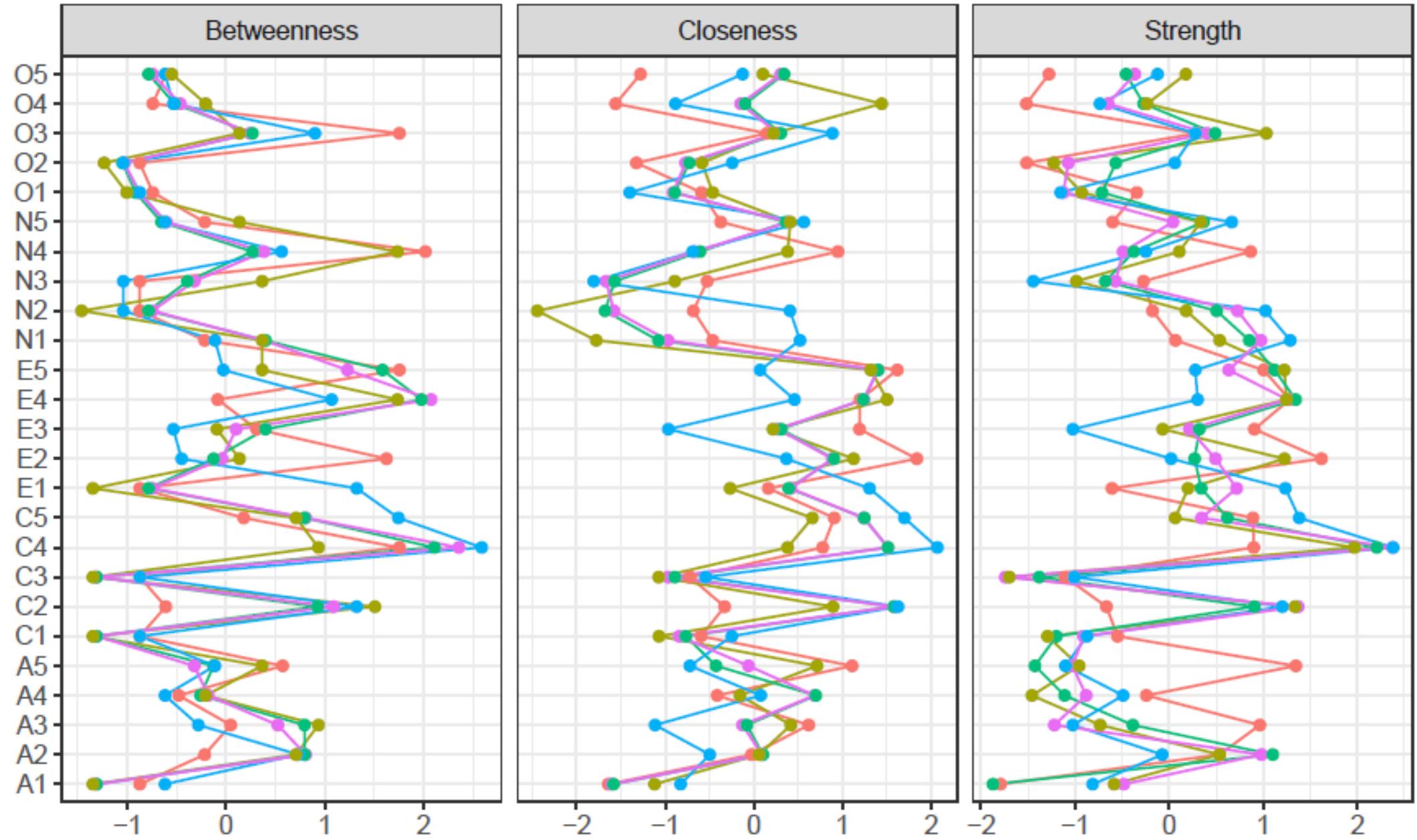
#### negativos

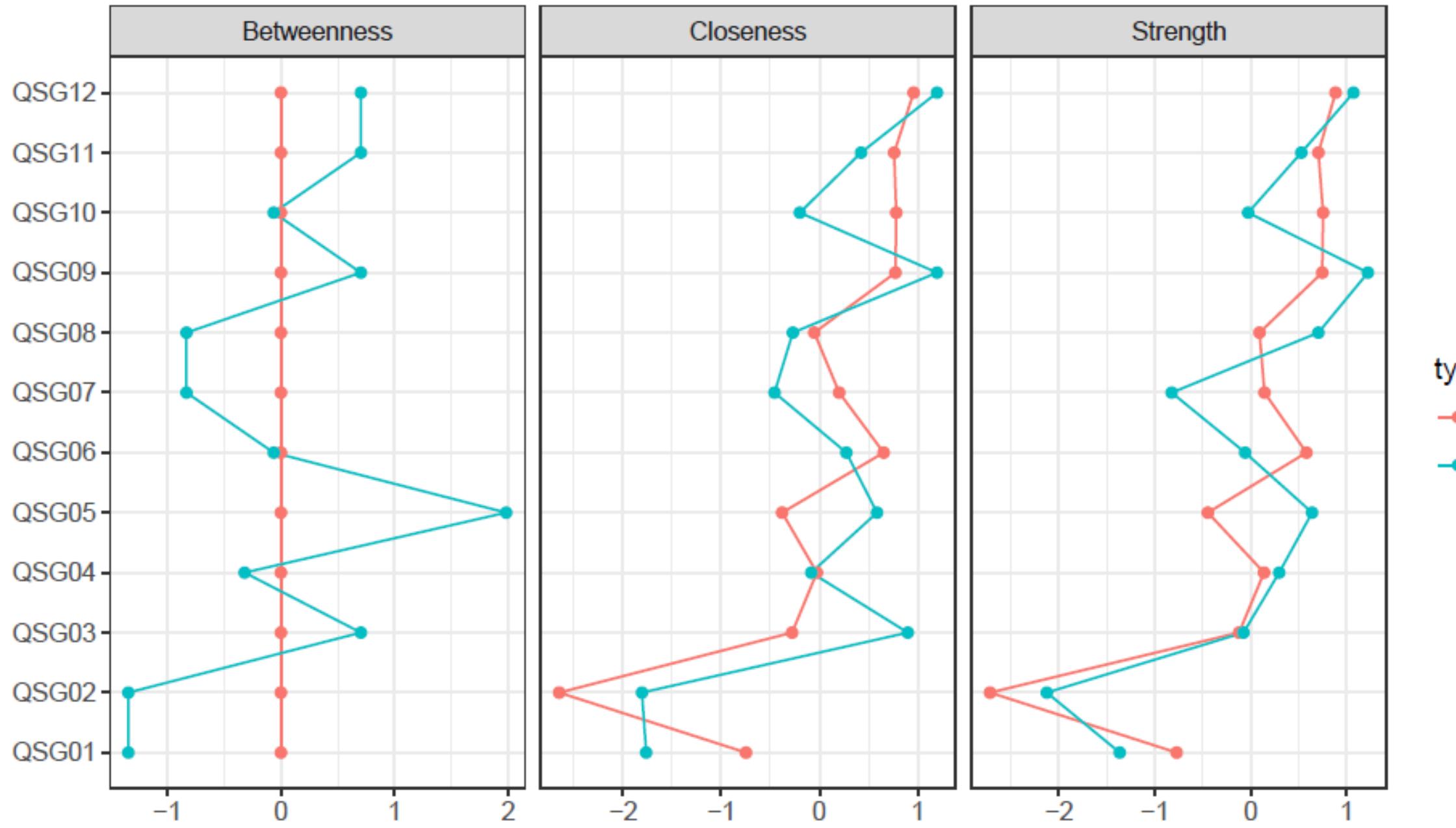
- QSG02: Suas preocupações o fazem perder o sono
- QSG05: Tem notado que está agoniado
- QSG06: Tem sensação de não superar dificuldades
- QSG09: Tem se sentido pouco feliz e deprimido
- QSG10: Tem perdido confiança em si mesmo
- QSG11: Tem pensado que não serve para nada

# Estatísticas descritivas da rede

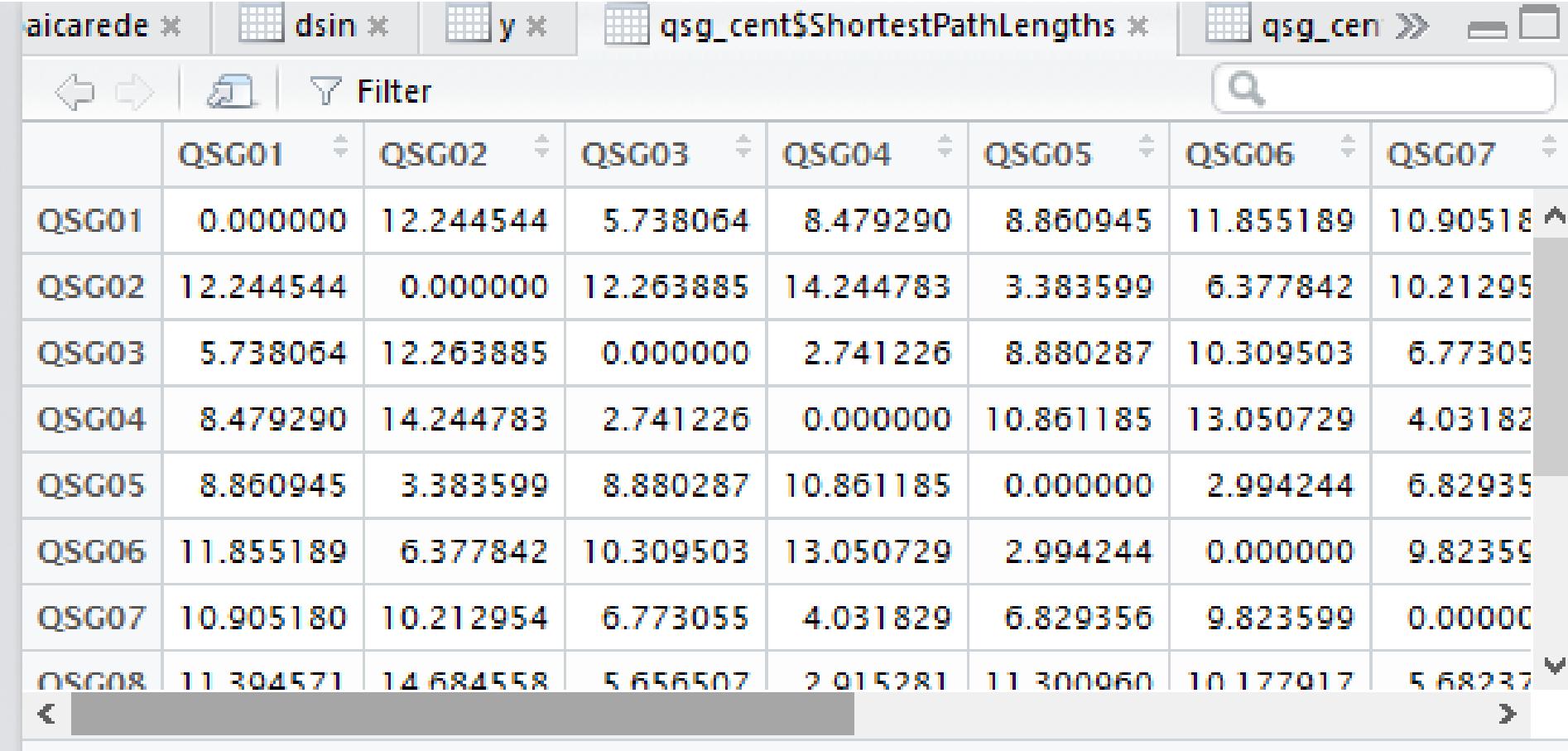
- Centralidade (centrality) – conjunto de medidas descritivas e estatísticas de uma rede
- Betweeness (conectividade) – considerando os menores caminhos entre todos os pares de variáveis na rede, quantas vezes a variável faz parte deste caminho (ponderado pelo número máximo possível)
- Closeness (proximidade) – é a soma do inverso da distância (path length) de todas as suas conexões (nos grafos não ponderados é chamado degree)
- Strength (força) – soma modular do peso de todas as suas conexões
- Shortest path – menor caminho considerando o número ou o peso das arestas
- Shortest path length – soma dos pesos do caminho menos caminho entre os pares conectados

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





Shortest path length – quanto menor, mais eficiente é o “caminho” e transmissão de informação



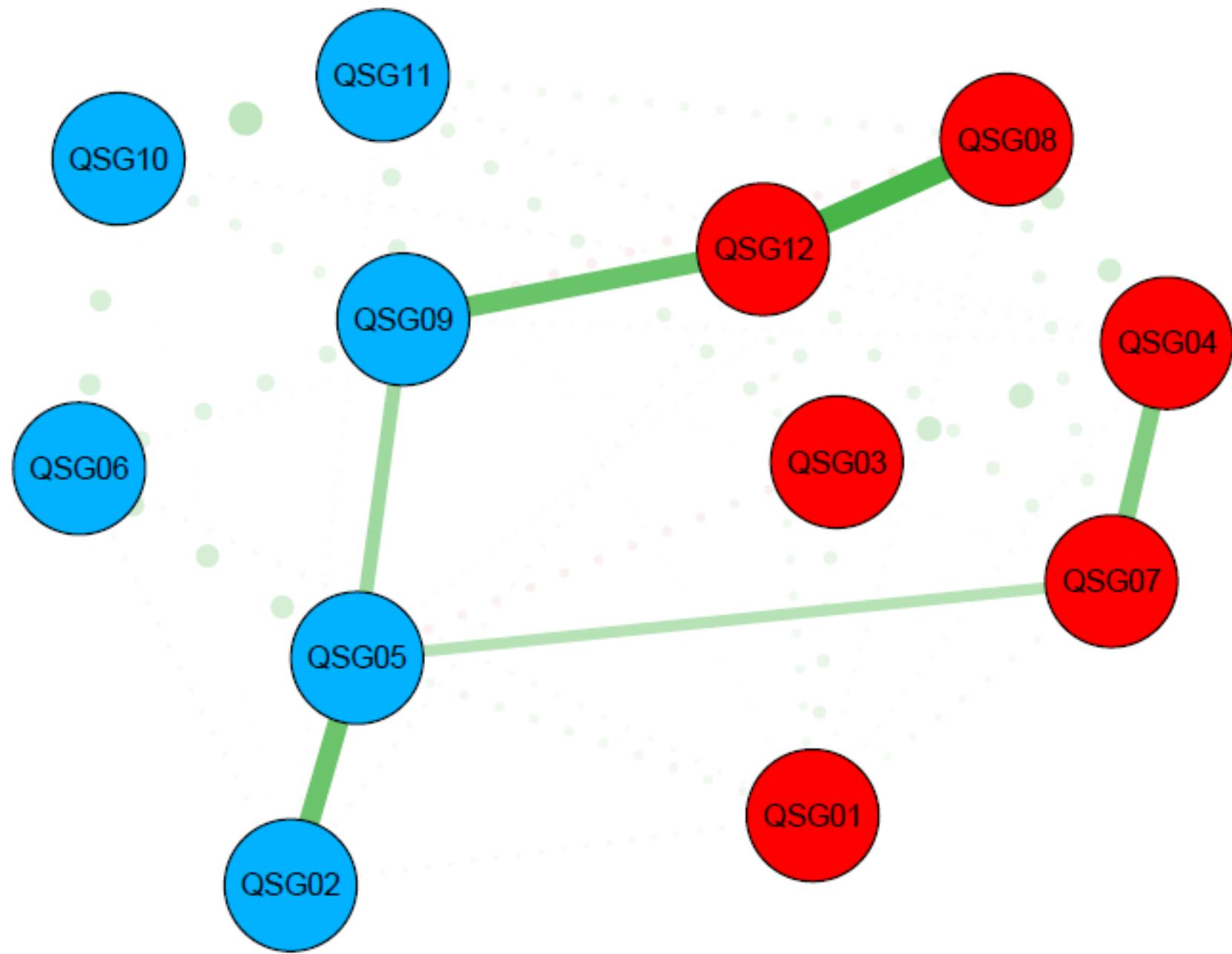
The screenshot shows a Jupyter Notebook interface with several tabs at the top: 'aicarede', 'dsin', 'y', 'qsg\_cent\$ShortestPathLengths' (which is the active tab), and 'qsg\_cen'. Below the tabs is a toolbar with icons for back, forward, refresh, and search. The main area displays a data frame with 8 columns labeled QSG01 through QSG08 and 8 rows labeled QSG01 through QSG08. The values represent shortest path lengths between nodes. The data frame is scrollable, with a vertical scrollbar on the right side.

	QSG01	QSG02	QSG03	QSG04	QSG05	QSG06	QSG07
QSG01	0.000000	12.244544	5.738064	8.479290	8.860945	11.855189	10.905180
QSG02	12.244544	0.000000	12.263885	14.244783	3.383599	6.377842	10.212954
QSG03	5.738064	12.263885	0.000000	2.741226	8.880287	10.309503	6.773055
QSG04	8.479290	14.244783	2.741226	0.000000	10.861185	13.050729	4.031829
QSG05	8.860945	3.383599	8.880287	10.861185	0.000000	2.994244	6.829355
QSG06	11.855189	6.377842	10.309503	13.050729	2.994244	0.000000	9.823599
QSG07	10.905180	10.212954	6.773055	4.031829	6.829356	9.823599	0.000000
QSG08	11.304571	14.684558	5.656507	2.015281	11.300060	10.177017	5.682370

Shortest path – o menor caminho é direto ou mediado?  
Redes regularizadas de correlação parcial (GeLasso) são  
redes de mediação!

The screenshot shows a RStudio interface with three tabs at the top: "qsg\_center\$ShortestPathLengths", "qsg\_center\$ShortestPaths", and "getWma". The "qsg\_center\$ShortestPathLengths" tab is active, displaying a grid of shortest path lengths between nodes QSG01 through QSG08. The "qsg\_center\$ShortestPaths" tab shows the corresponding shortest paths as lists of node indices. The "getWma" tab is also visible.

	QSG01	QSG02	QSG03	QSG04	QSG05
QSG01	list()	list(c(1, 5, 2))	list(c(1, 3))	list(c(1, 3, 4))	list(
QSG02	list(c(2, 5, 1))	list()	list(c(2, 5, 3))	list(c(2, 5, 7, 4))	list(
QSG03	list(c(3, 1))	list(c(3, 5, 2))	list()	list(c(3, 4))	list(
QSG04	list(c(4, 3, 1))	list(c(4, 7, 5, 2))	list(c(4, 3))	list()	list(
QSG05	list(c(5, 1))	list(c(5, 2))	list(c(5, 3))	list(c(5, 7, 4))	list(
QSG06	list(c(6, 5, 1))	list(c(6, 5, 2))	list(c(6, 10, 11, 3))	list(c(6, 10, 11, 3, 4))	list(
QSG07	list(c(7, 1))	list(c(7, 5, 2))	list(c(7, 4, 3))	list(c(7, 4))	list(
QSG08	list(c(8, 4, 3, 1))	list(c(8, 12, 0, 5, 2))	list(c(8, 4, 3))	list(c(8, 4))	list(



#### positivos

- QSG01: Tem podido concentrar-se no que faz
- QSG03: Tem sentido que tem papel útil na vida
- QSG04: Tem sido capaz de tomar decisões
- QSG07: Tem sido capaz de desfrutar de atividades
- QSG08: Tem sido capaz de enfrentar problemas
- QSG12: Sente-se razoavelmente feliz

#### negativos

- QSG02: Suas preocupações o fazem perder o sono
- QSG05: Tem notado que está agoniado
- QSG06: Tem sensação de não superar dificuldades
- QSG09: Tem se sentido pouco feliz e deprimido
- QSG10: Tem perdido confiança em si mesmo
- QSG11: Tem pensado que não serve para nada

# Matriz adjacente (GeLasso) – betas de regressão linear múltipla!

The screenshot shows a data frame in RStudio with 8 rows and 7 columns. The columns are labeled QSG01, QSG02, QSG03, QSG04, QSG05, QSG06, and QSG07. The rows are labeled QSG01 through QSG08. The matrix contains numerical values representing beta coefficients. The diagonal elements are all zero, indicating no self-loops. The matrix is symmetric, reflecting the properties of an adjacency matrix.

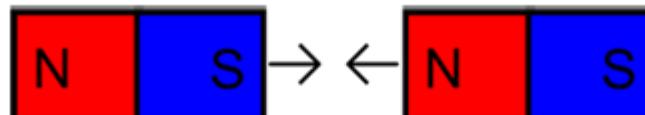
	QSG01	QSG02	QSG03	QSG04	QSG05	QSG06
QSG01	0.00000000	-0.05503783	0.17427480	0.05202109	0.11285478	0.06677430
QSG02	-0.05503783	0.00000000	0.00000000	0.00000000	0.29554334	0.06167212
QSG03	0.17427480	0.00000000	0.00000000	0.36480023	-0.11260898	0.00000000
QSG04	0.05202109	0.00000000	0.36480023	0.00000000	0.00000000	0.00000000
QSG05	0.11285478	0.29554334	-0.11260898	0.00000000	0.00000000	0.33397413
QSG06	0.06677431	0.06167213	0.00000000	0.00000000	0.33397414	0.00000000
QSG07	0.09169954	0.00000000	0.00000000	0.24802639	0.14642670	0.00051071
QSG08	0.05006202	0.00000000	0.00000000	0.34302016	-0.03110161	0.03800027

# Dados dicotômicos?

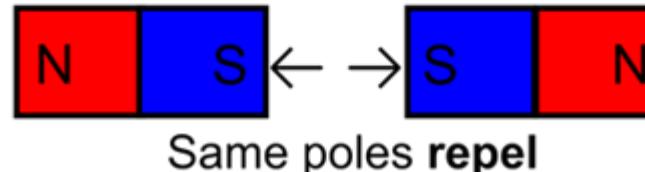
- Na Psicologia, Saúde e Educação não são raros os instrumentos que resultam em dados dicotômicos (presença/ausência, acerto/erro, etc.)
- Se para os dados Gaussianos utiliza-se regressões lineares múltiplas regularizadas, então...
- Regressão logística! Yes!

# 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<sup>1,2</sup>, Denny Borsboom<sup>2</sup>, Sacha Epskamp<sup>2</sup>, Tessa F. Blanken<sup>2</sup>, Lynn Boschloo<sup>1</sup>, Robert A. Schoevers<sup>1</sup> & Lourens J. Waldorp<sup>2</sup>

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

where  $\tau_j$  and  $\beta_{jk}$  are the node parameter (or threshold) and the pairwise interaction parameter respectively.

# Network Psychometrics

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

University of Amsterdam, Department of Psychological Methods

2016

## Abstract

This chapter provides a general introduction of network modeling in psychometrics. The chapter starts with an introduction to the statistical model formulation of pairwise Markov random fields (PMRF), followed by an introduction of the PMRF suitable for binary data: the *Ising model*. The Ising model is a model used in ferromagnetism to explain phase transitions in a

## The Relation Between the Ising Model and Item Response Theory

In this section we will show that the Ising model is a closely related modeling framework of Item Response Theory (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 2-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.

# DASS

Nome:

Data:

Por favor, leia cada afirmativa e marque um dos números (0, 1, 2 ou 3) que indique quanto a afirmativa se aplica a você. Não há respostas certas ou erradas. Não gaste muito tempo em nenhuma das afirmativas.

0. Não se aplicou a mim de forma alguma
1. Aplicou-se a mim de alguma forma ou em algumas vezes
2. Aplicou-se a mim de forma considerável ou em boa parte do tempo
3. Aplicou-se muito a mim ou na maior parte do tempo

1 Eu tive dificuldade para me acalmar

0 1 2 3

2 Eu percebi que estava com a boca seca

0 1 2 3

# Preparação

```
dass_sub<-dass[2:22]
```

```
View(dass_sub)
```

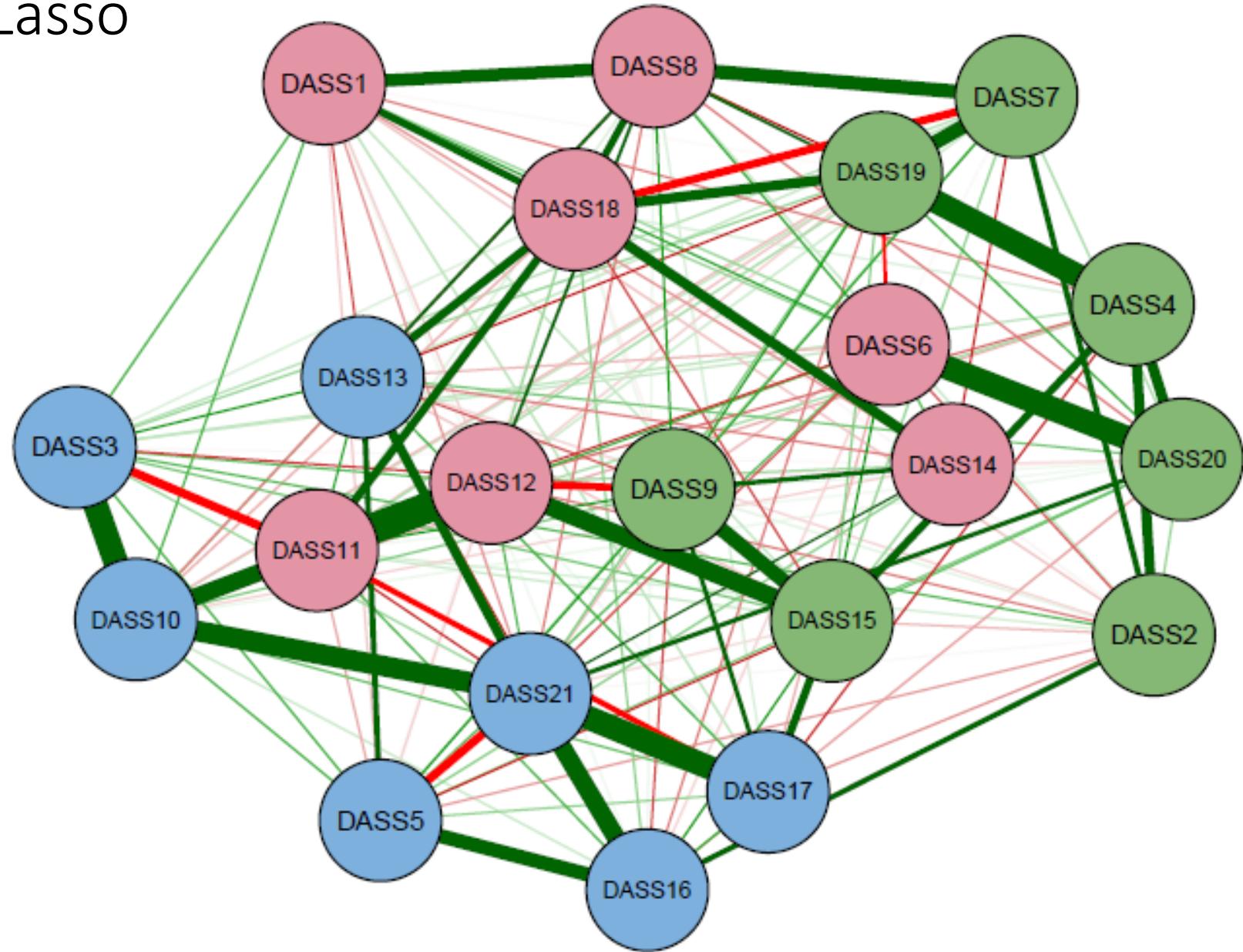
```
namesdass<-
```

```
list("1.wind","2.drymth","3.posfeel","4.breatdiff","5.init","6.ovreact","7.tremb","8.nervener","9.panfool","10.lookfor","11.gettagit","12.relax","13.blue","14.intol","15.panic","16.enthu","17.worth","18.rattouch","19.heartphys","20.scareas","21.meaning")
```

```
dass_groups<-
```

```
list("stress"=c(1,6,8,11,12,14,18),"anxiety"=c(2,4,7,9,15,19,20),"depression"=c(3,5,10,13,16,17,21))
```

# GeLasso



## stress

- DASS1: 1.wind
- DASS6: 6.ovreact
- DASS8: 8.nervener
- DASS11: 11.gettagit
- DASS12: 12.relax
- DASS14: 14.intol
- DASS18: 18.rattouch

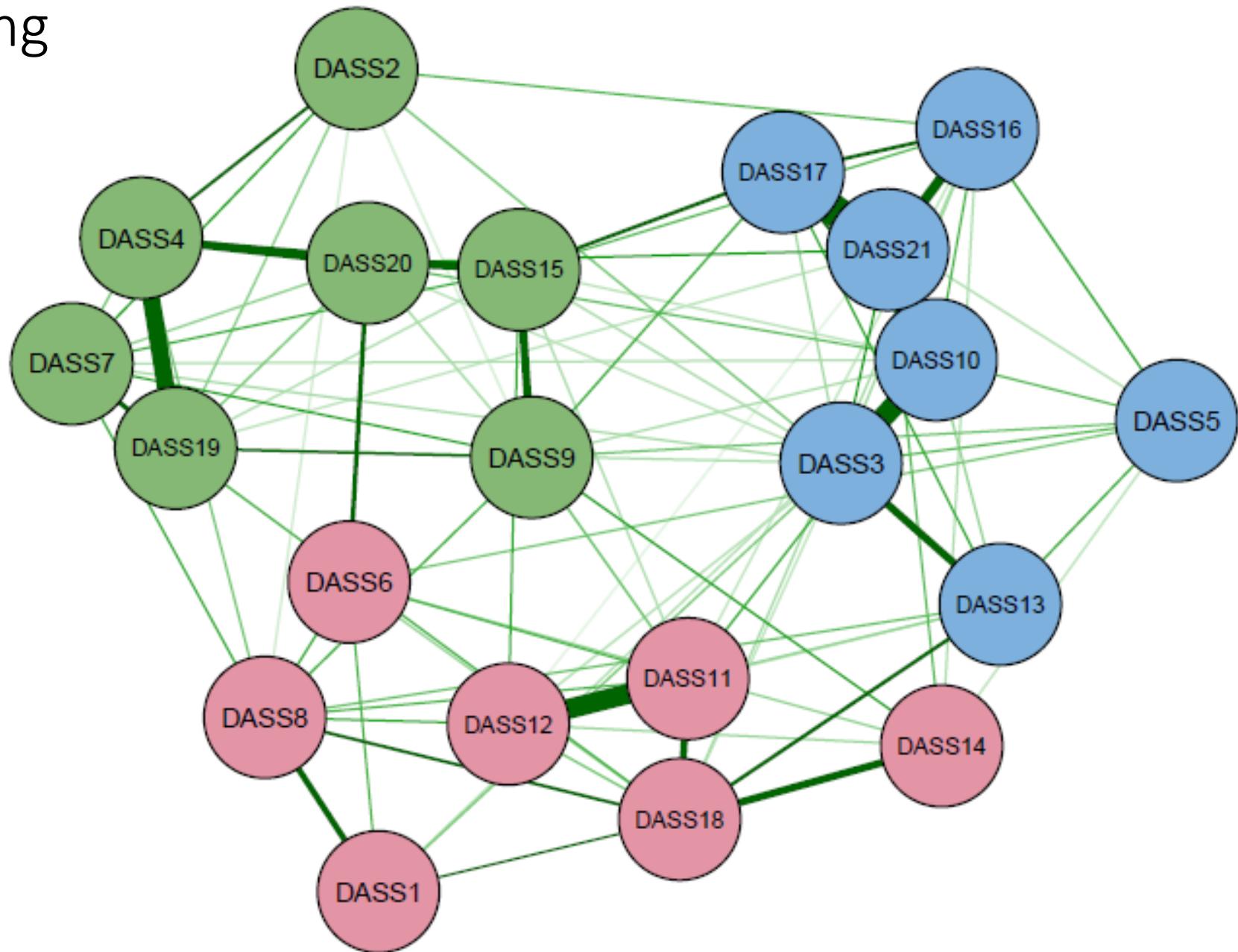
## anxiety

- DASS2: 2.drymth
- DASS4: 4.breatdiff
- DASS7: 7.trembl
- DASS9: 9.panfool
- DASS15: 15.panic
- DASS19: 19.heartphys
- DASS20: 20.scareas

## depression

- DASS3: 3.posfeel
- DASS5: 5.init
- DASS10: 10.lookfor
- DASS13: 13.blue
- DASS16: 16.enthu
- DASS17: 17.worth
- DASS21: 21.meaning

Ising



#### stress

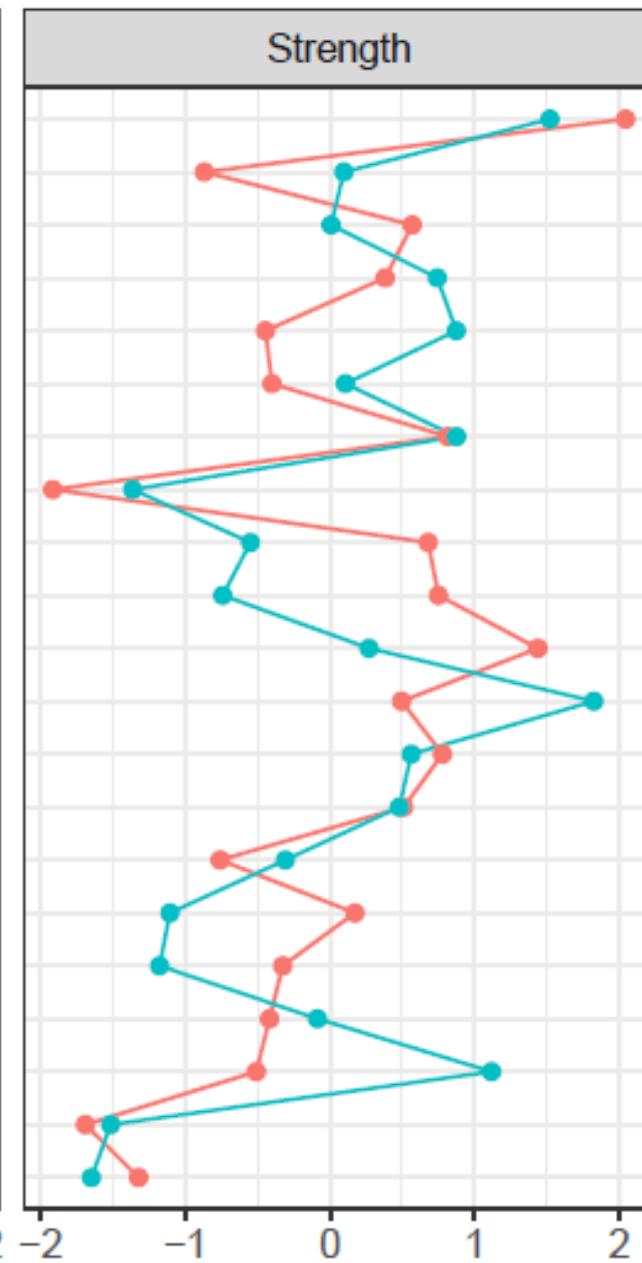
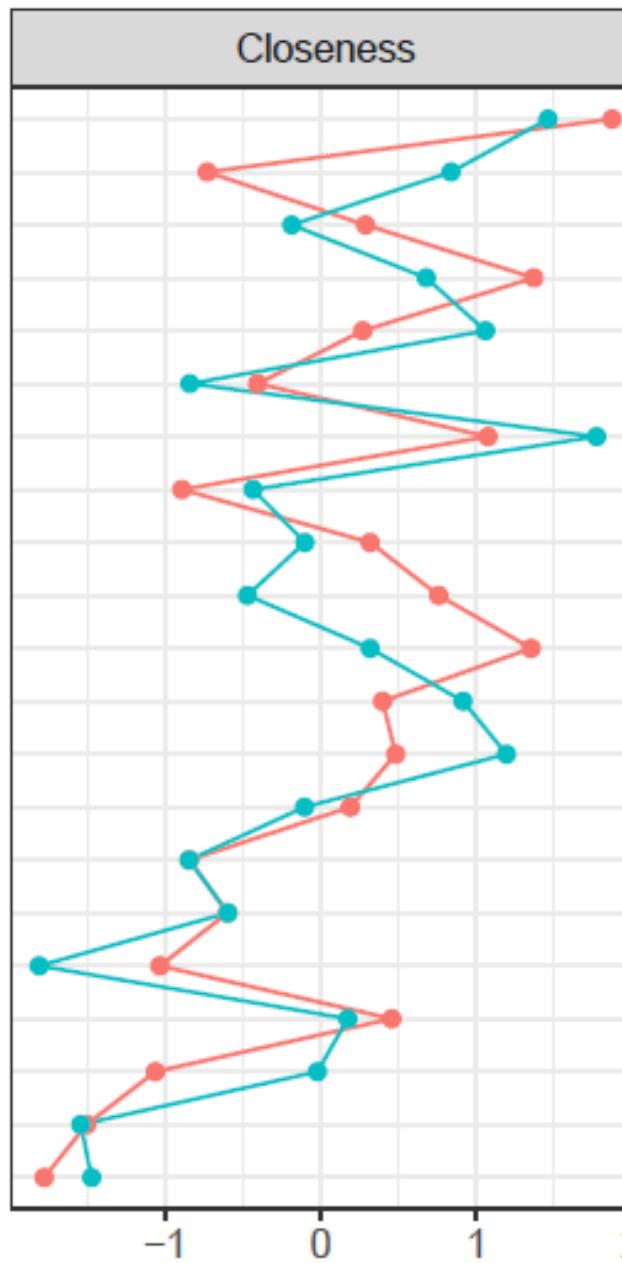
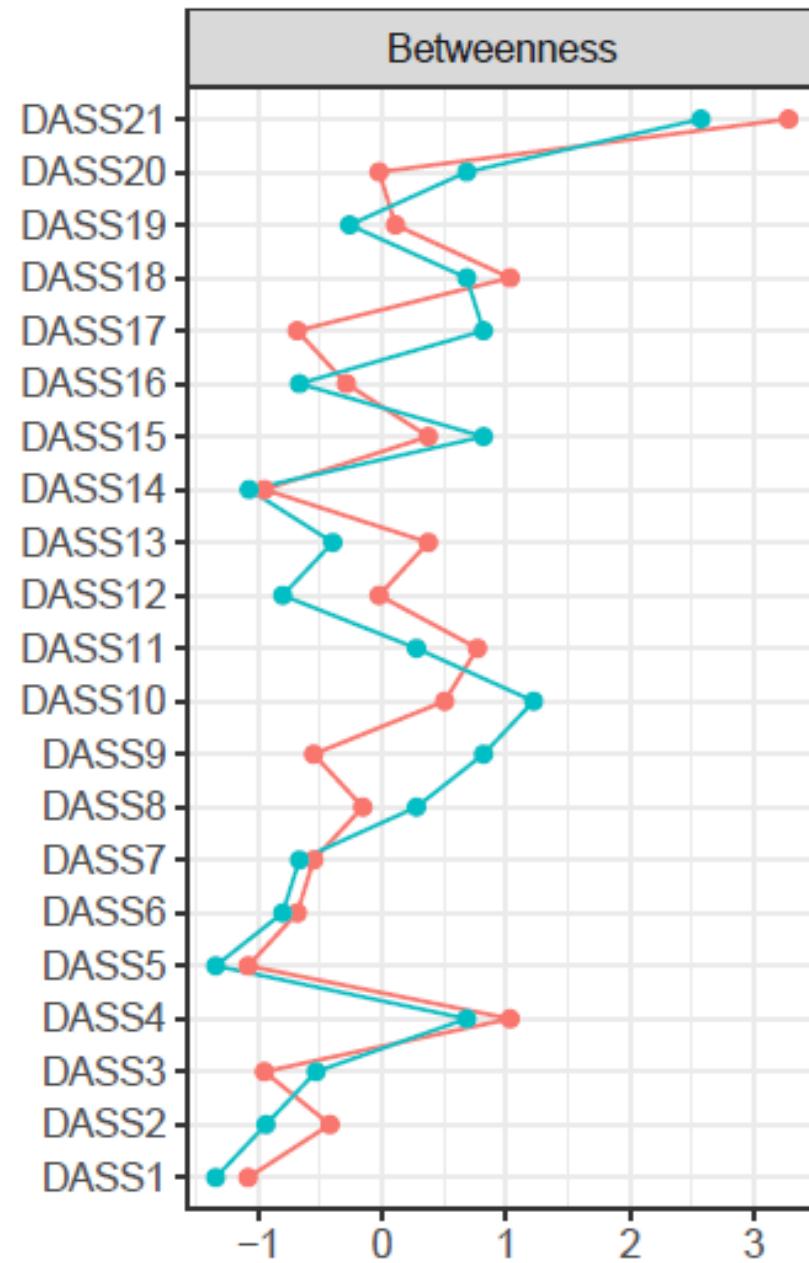
- DASS1: 1.wind
- DASS6: 6.ovreact
- DASS8: 8.nervener
- DASS11: 11.gettagit
- DASS12: 12.relax
- DASS14: 14.intol
- DASS18: 18.rattouch

#### anxiety

- DASS2: 2.drymth
- DASS4: 4.breatdiff
- DASS7: 7.tremb
- DASS9: 9.panfool
- DASS15: 15.panic
- DASS19: 19.heartphys
- DASS20: 20.scareas

#### depression

- DASS3: 3.posfeel
- DASS5: 5.init
- DASS10: 10.lookfor
- DASS13: 13.blue
- DASS16: 16.enthu
- DASS17: 17.worth
- DASS21: 21.meaning



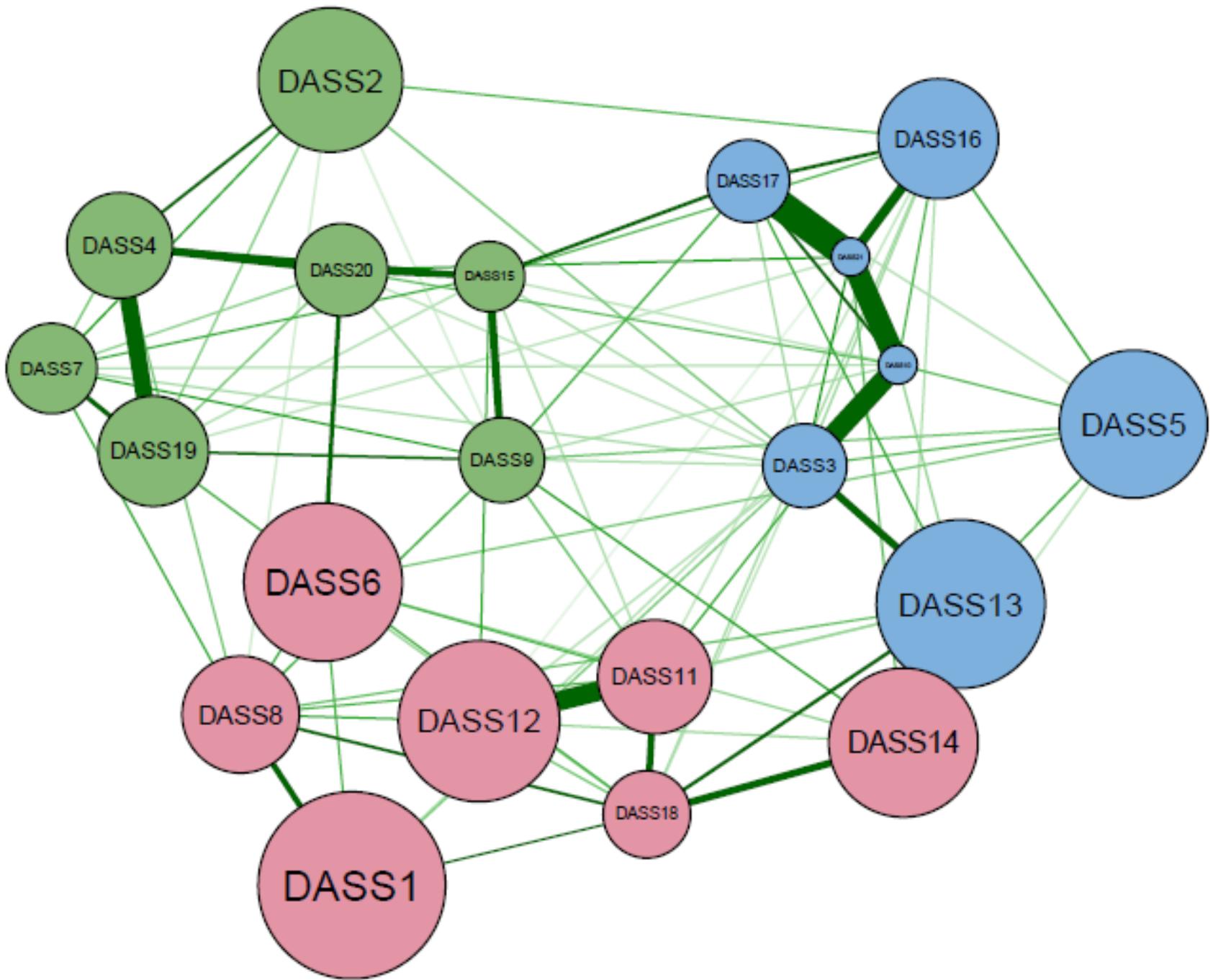
type

- GeLasso
- Ising

## dass\_ising\$thresholds

```
> dass_ising$thresholds
```

DASS1	DASS2	DASS3	DASS4	DASS5
-0.1179269	-1.2356752	-2.8089300	-2.2411057	-1.1422524
DASS6	DASS7	DASS8	DASS9	DASS10
-0.8712178	-2.6446057	-1.9478597	-2.7809815	-3.9904660
DASS11	DASS12	DASS13	DASS14	DASS15
-2.0258820	-0.7975360	-0.6003909	-1.1090307	-3.1695024
DASS16	DASS17	DASS18	DASS19	DASS20
-1.8677412	-2.8432269	-2.7238942	-2.1216984	-2.5878984
DASS21				
-4.0047676				



#### stress

- DASS1: 1.wind
- DASS6: 6.ovreact
- DASS8: 8.nervener
- DASS11: 11.gettagit
- DASS12: 12.relax
- DASS14: 14.intol
- DASS18: 18.rattouch

#### anxiety

- DASS2: 2.drymth
- DASS4: 4.breatdiff
- DASS7: 7.tremb
- DASS9: 9.panfool
- DASS15: 15.panic
- DASS19: 19.heartphys
- DASS20: 20.scareas

#### depression

- DASS3: 3.posfeel
- DASS5: 5.init
- DASS10: 10.lookfor
- DASS13: 13.blue
- DASS16: 16.enthu
- DASS17: 17.worth
- DASS21: 21.meaning

## View(dass\_cent\$ShortestPaths)

	DASS1	DASS2	DASS3	DASS4
DASS1	list()	list(c(1, 8, 7, 2))	list(c(1, 3))	list(c(1, 8, 4))
DASS2	list(c(2, 7, 8, 1))	list()	list(c(2, 3))	list(c(2, 4))
DASS3	list(c(3, 1))	list(c(3, 2))	list()	list(c(3, 10, 21, 19, 4))
DASS4	list(c(4, 8, 1))	list(c(4, 2))	list(c(4, 20, 21, 10, 3))	list()
DASS5	list(c(5, 13, 18, 1))	list(c(5, 16, 2))	list(c(5, 3))	list(c(5, 9, 19, 4))
DASS6	list(c(6, 1))	list(c(6, 20, 4, 2))	list(c(6, 20, 21, 10, 3))	list(c(6, 20, 4))
DASS7	list(c(7, 8, 1))	list(c(7, 2))	list(c(7, 3))	list(c(7, 19, 4))
DASS8	list(c(8, 1))	list(c(8, 7, 2))	list(c(8, 13, 3))	list(c(8, 4))

## View(dass\_ising\$weiadj)

	DASS1	DASS2	DASS3	DASS4	DASS5	DASS6	DASS7
DASS4	0.0000000	0.7249200	0.0000000	0.0000000	0.0000000	0.0000000	0.36604
DASS5	0.0000000	0.0000000	0.4543805	0.0000000	0.0000000	0.3668149	0.00000
DASS6	0.4966041	0.0000000	0.0000000	0.0000000	0.3668149	0.0000000	0.00000
DASS7	0.0000000	0.6237433	0.2356706	0.3660434	0.0000000	0.0000000	0.00000
DASS8	0.8391341	0.1259954	0.0000000	0.3755290	0.0000000	0.5420260	0.55125
DASS9	0.0000000	0.1108908	0.0000000	0.0000000	0.3972706	0.0000000	0.61023
DASS10	0.2001959	0.0000000	1.4777947	0.0000000	0.4479508	0.0000000	0.21298

# Redes de dados misturados (mixed)

- É comum ter dados de diferentes níveis de mensuração
- Gaussianos, contagens (discretas e positivas, dicotômicas, etc.)
- Número de vezes que procurou serviço de saúde
- Score em uma escala de qualidade de vida
- Gênero
- É preciso utilizar o modelo linear
- Método: generalized covariance matrices of mixed joint distributions



*Journal of Statistical Software*

MMMMMM YYYY, Volume VV, Issue II.

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

mgm: Structure Estimation for time-varying Mixed Graphical Models in high-dimensional Data

2011

Jonas M. B. Haslbeck

Lourens J. Waldorp

*Submitted to the Annals of Applied Statistics*

STRUCTURE ESTIMATION FOR MIXED GRAPHICAL MODELS IN HIGH-DIMENSIONAL DATA

BY JONAS M. B. HASLBECK

Utrecht University  
AND

BY LOURENS J. WALDORP

University of Amsterdam

## View(smmix)

	<b>Id</b>	<b>Sex</b>	<b>Esc</b>	<b>Atv</b>	<b>Ric</b>	<b>Rend</b>	<b>Tvol</b>	<b>Pre</b>	<b>SG</b>	<b>EP</b>	<b>SM</b>
46	35	1	2	3	1	10000	2	2	-0.11863235	-0.56906658	0.21327303
48	32	1	2	1	1	2000	2	1	0.53416597	-0.16147631	-0.05099198
49	39	1	2	2	1	8000	2	1	-0.03733537	-0.28882954	0.53037681
53	23	1	2	2	1	2500	1	2	0.64731763	0.37319223	-0.12456924
57	26	1	0	3	1	730	2	1	0.06208173	-0.27076626	0.75655382
58	26	1	2	1	1	2000	2	1	0.01113756	0.35633705	0.33005960
61	30	1	2	1	1	2000	2	1	-1.16311943	-1.40868239	1.04797721
64	40	1	1	2	2	3500	1	1	0.30701164	1.04406006	-1.18037254

```
lm(formula = smmix$SM ~ smmix$Id + smmix$Sex + smmix$Esc + smmix$Atv + smmix$Ric +  
smmix$Rend + smmix$Tvol + smmix$Pre + smmix$SG + smmix$EP, data = smmix)
```

**Coefficients:**

	Estimate	Std. Error	t value	Pr(> t )	
(Intercept)	3.393e-01	3.440e-01	0.986	0.324800	.
smmix\$Id	7.799e-03	4.248e-03	1.836	0.067320	.
smmix\$Sex	1.722e-01	9.108e-02	1.890	0.059679	.
smmix\$Esc	-2.056e-02	5.850e-02	-0.352	0.725448	
smmix\$Atv	4.492e-02	5.654e-02	0.794	0.427578	
smmix\$Ric	-1.376e-01	8.815e-02	-1.561	0.119619	
smmix\$Rend	5.535e-06	1.548e-05	0.358	0.720833	
smmix\$Tvol	-3.256e-01	8.939e-02	-3.642	0.000317	***
smmix\$Pre	-1.407e-01	8.989e-02	-1.565	0.118669	
smmix\$SG	-3.386e-01	6.120e-02	-5.533	6.72e-08	***
smmix\$EP	-2.657e-01	6.030e-02	-4.406	1.45e-05	***
<hr/>					
Signif. codes:	0 ‘***’	0.001 ‘**’	0.01 ‘*’	0.05 ‘.’	0.1 ‘ ’ 1

Residual standard error: 0.6796 on 310 degrees of freedom

Multiple R-squared: 0.4617, Adjusted R-squared: 0.4443

F-statistic: 26.59 on 10 and 310 DF, p-value: < 2.2e-16

# stepwise

Stepwise Model Path  
Analysis of Deviance Table

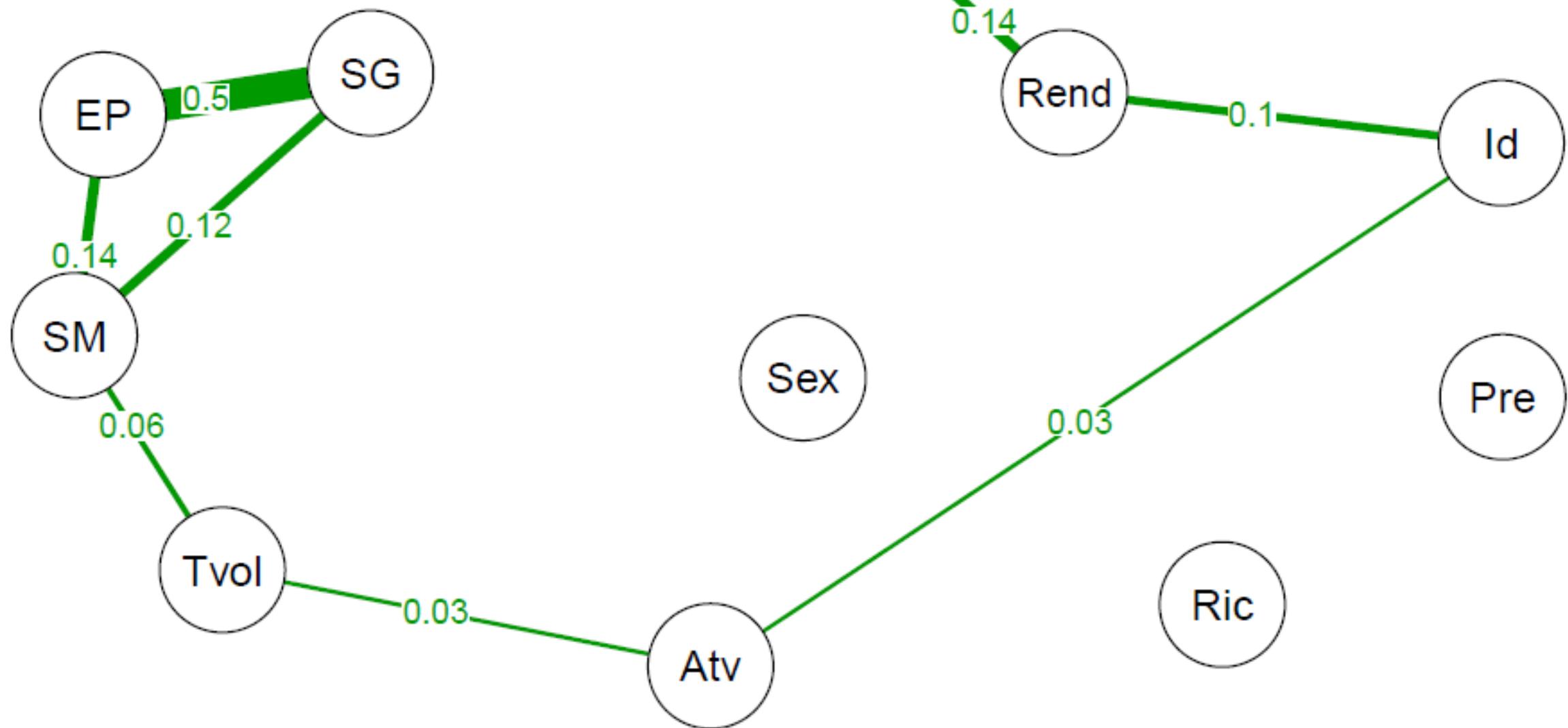
Initial Model:

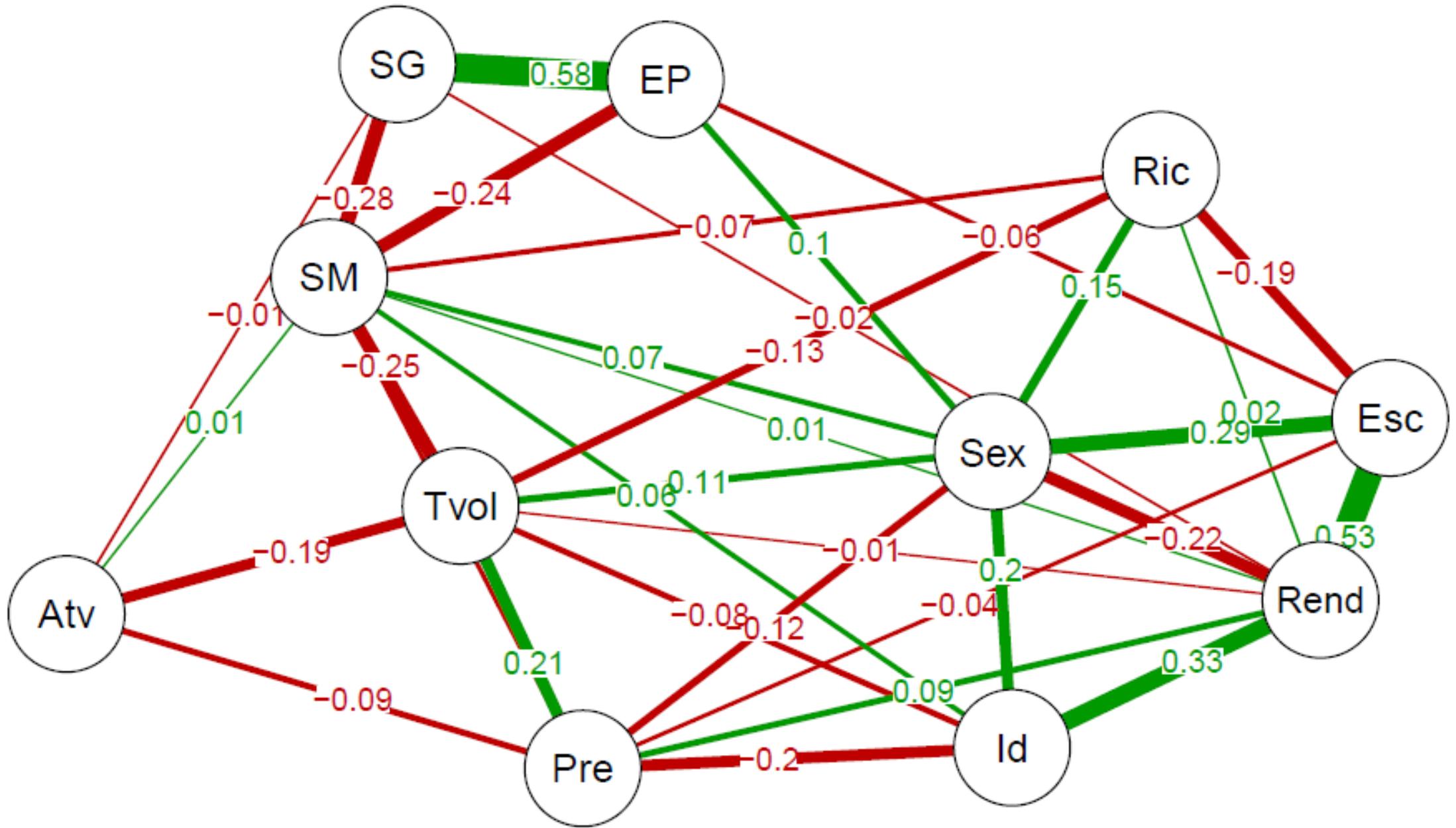
```
smmix$SM ~ smmix$Id + smmix$Sex + smmix$Esc + smmix$Atv + smmix$Ric +
    smmix$Rend + smmix$Tvol + smmix$Pre + smmix$SG + smmix$EP
```

Final Model:

```
smmix$SM ~ smmix$Id + smmix$Sex + smmix$Ric + smmix$Tvol + smmix$Pre +
    smmix$SG + smmix$EP
```

Step	Df	Deviance	Resid. Df	Resid. Dev	AIC
1			310	143.1766	-237.1633
2	- smmix\$Esc	1 0.05706563	311	143.2337	-239.0354
3	- smmix\$Rend	1 0.02766346	312	143.2613	-240.9734
4	- smmix\$Atv	1 0.29391817	313	143.5552	-242.3155
.					



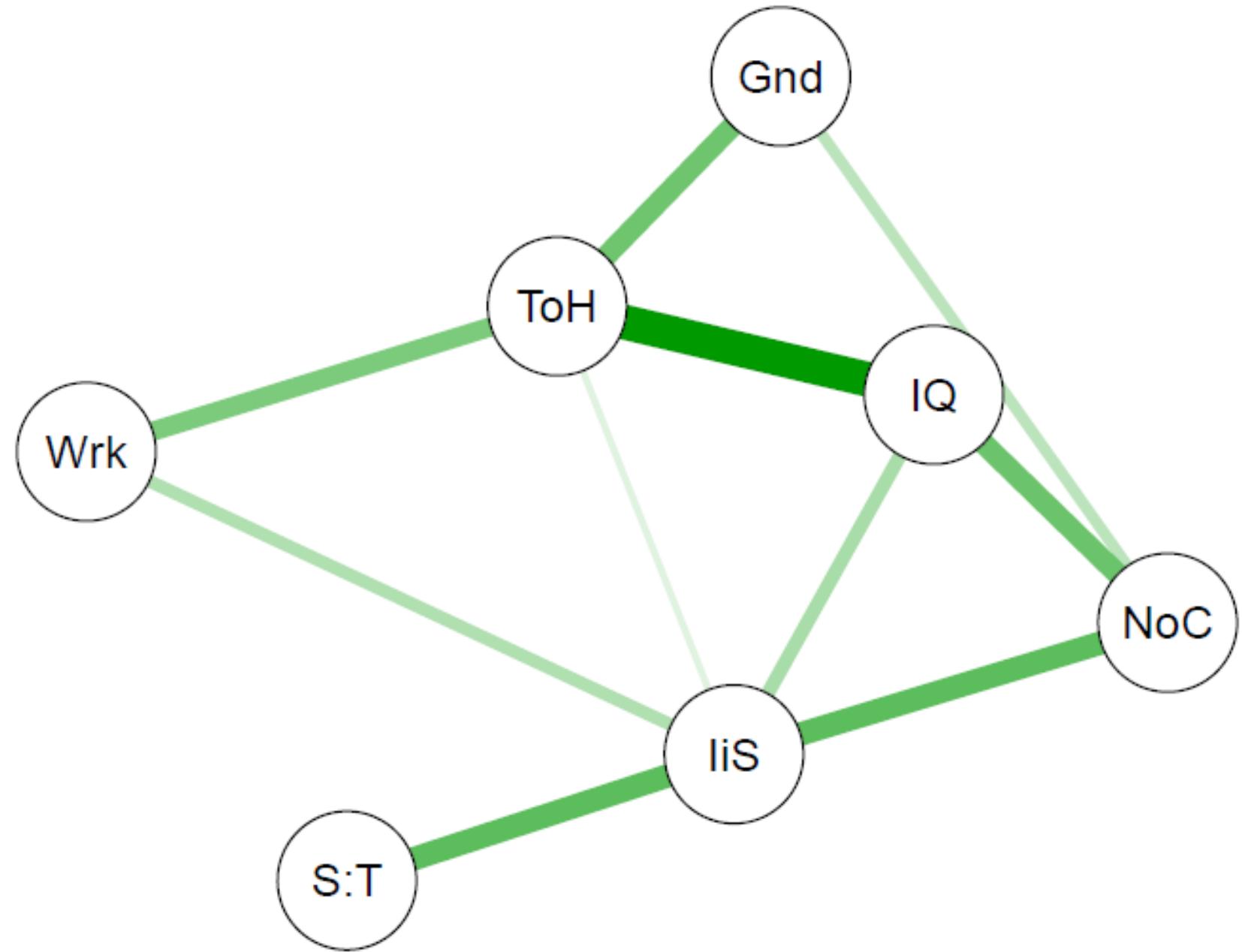


# Exemplo banco autismo

The screenshot shows the RStudio interface with the 'autism\_data' tab selected in the top navigation bar. Below the tabs is a toolbar with icons for back, forward, refresh, and search. The main area displays a data grid with the following columns:

.of.Housing	data.Workinghours	data.Satisfaction..Treatment	type	lev	colnames
1	0	3.000000	c	2	Gender
1	0	2.000000	g	1	IQ
1	0	4.000000	c	3	Integration
1	10	3.000000	p	1	No of Com
1	0	1.000000	c	2	Type of H
1	0	1.750000	g	1	Workingho
2	31	2.330000	g	1	Satisfaction

At the bottom of the grid are navigation arrows for horizontal scrolling.



Gnd: Gender

IQ: IQ

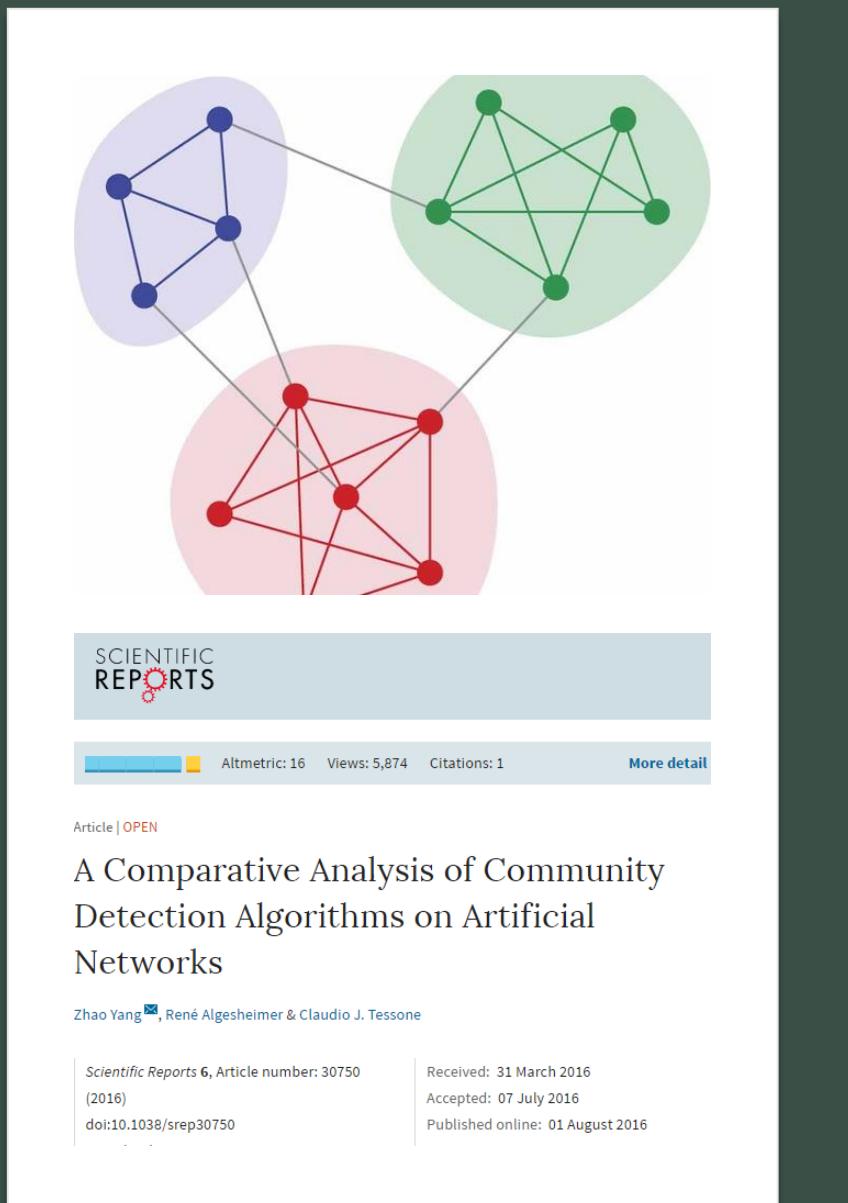
IIS: Integration in Society

NoC: No of Comorbidities

ToH: Type of Housing

Wrk: Workinghours

S:T: Satisfaction: Treatment

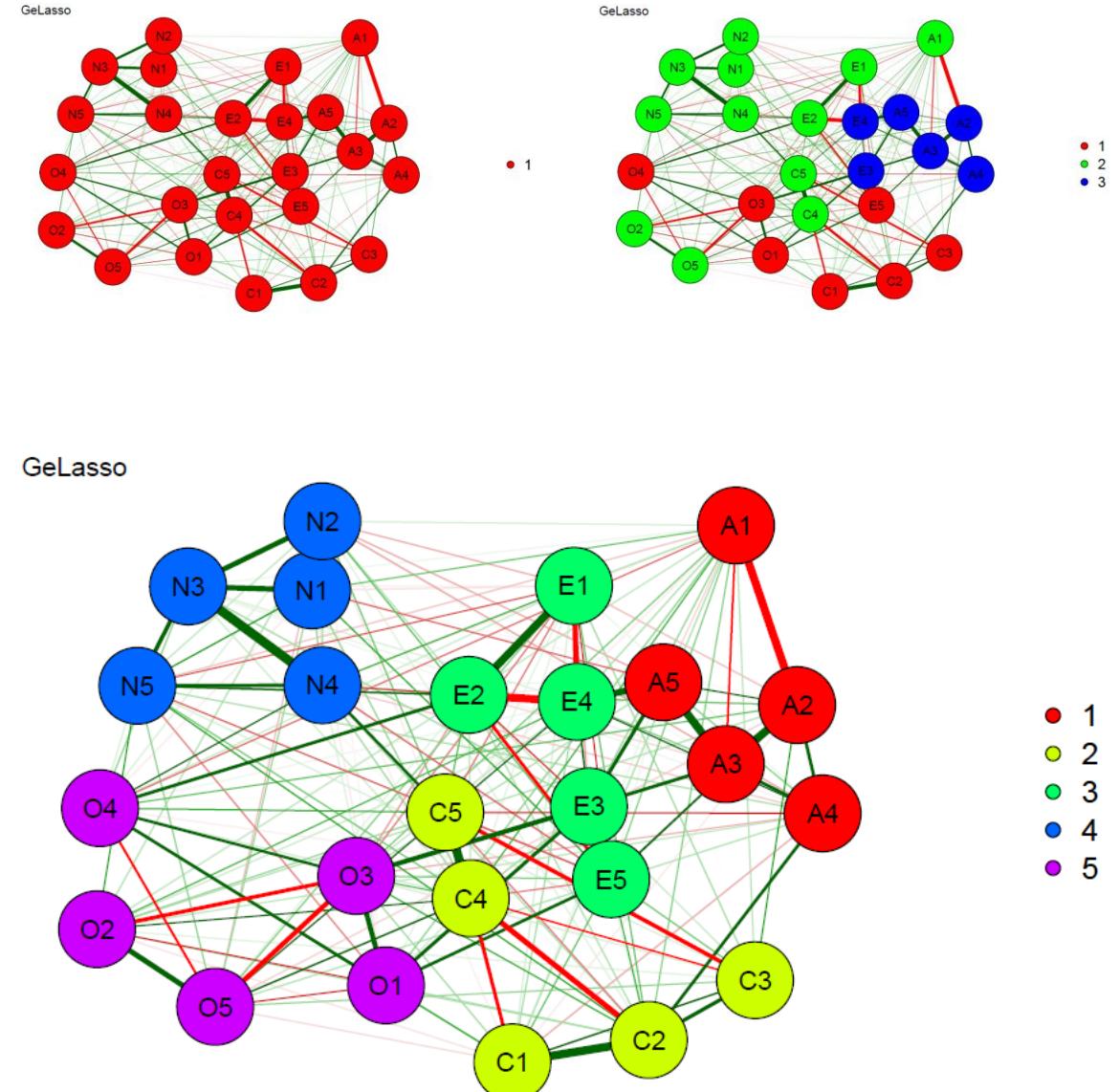


# Análise de comunidades

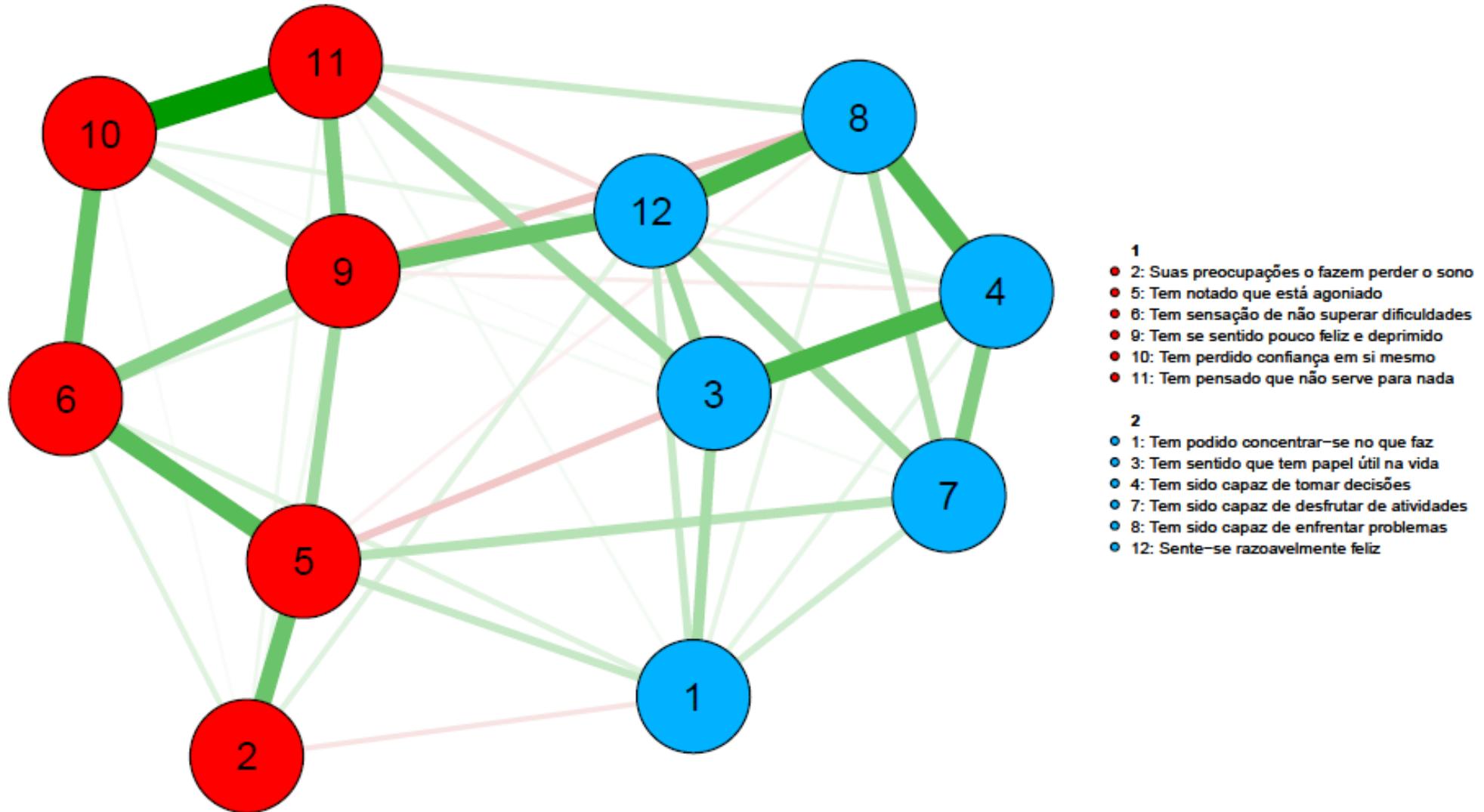
- Existem subgrupos de variáveis ou observações na rede?
- Três métodos mais populares:
  - Waltrap – parte de passos aleatórios e vai decompondo o conjunto em  $N-1$  comunidades, calculando a distância das arestas entre e dentre comunidades
  - Spinglass – baseado também em um modelo do ferromagnetismo (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)

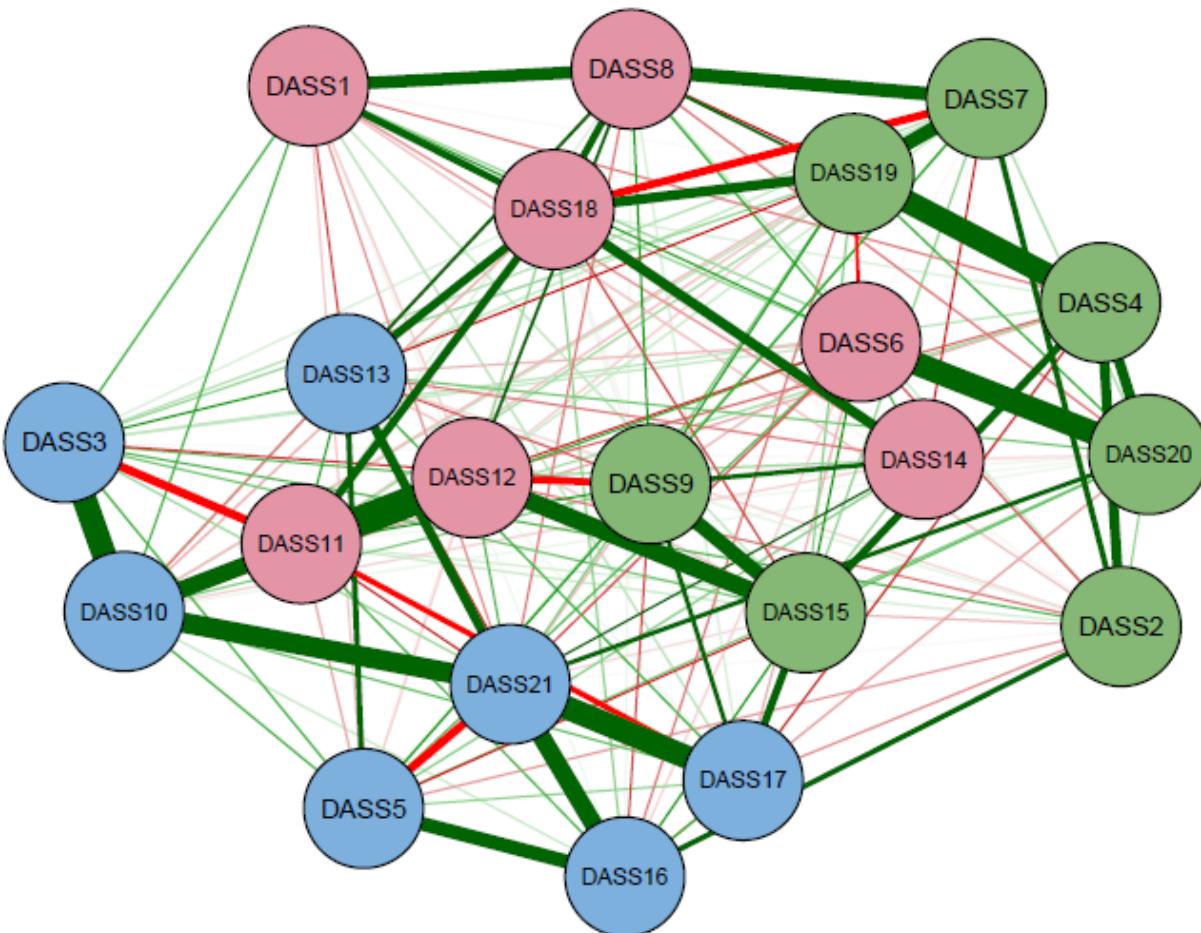
# Desempenho

- Walktrap = 1 comunidade
- Spinglass = 3 comunidades
- Louvain = 5 comunidades\*



# QSG – 1 ou 2 “clusters”





**stress**

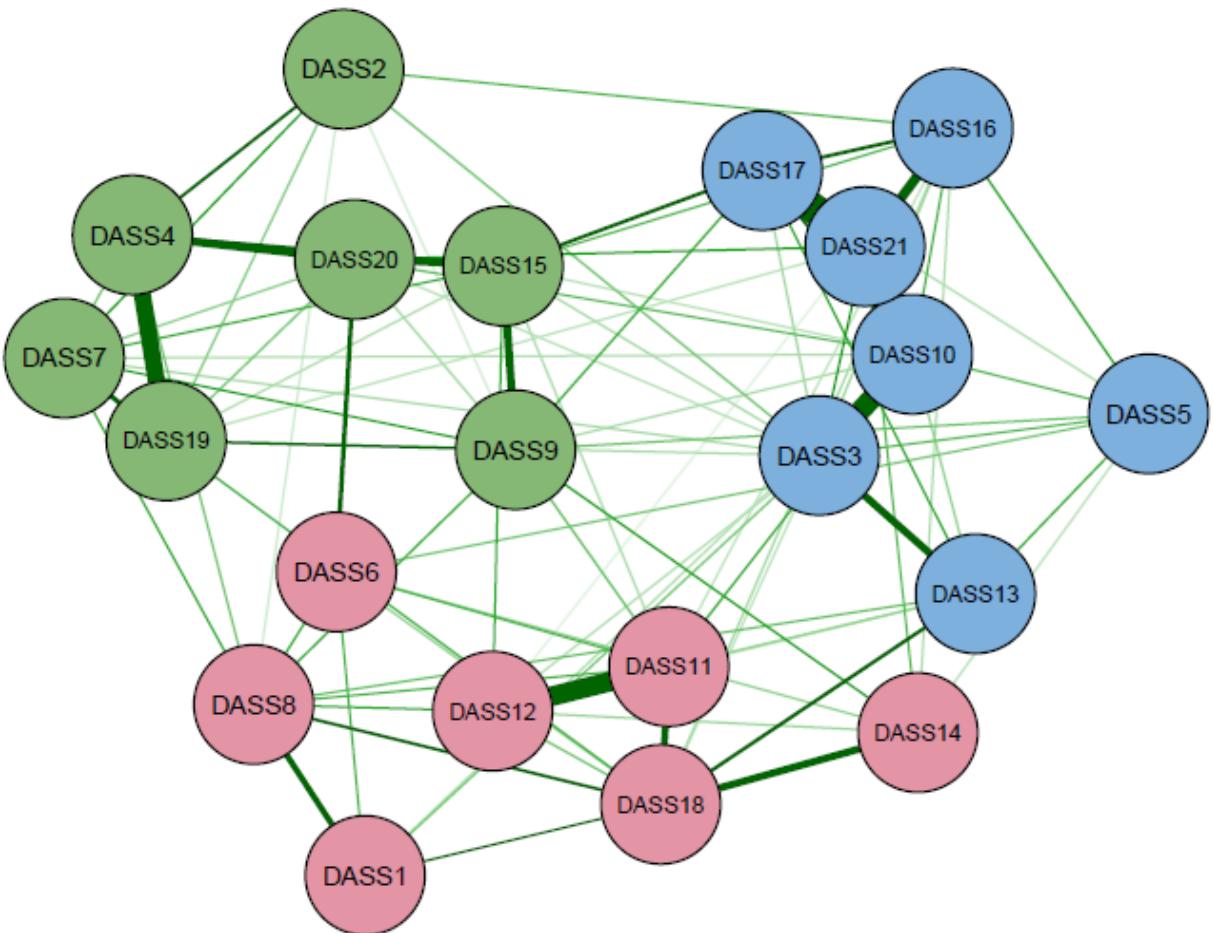
- DASS1: 1.wind
- DASS6: 6.ovreact
- DASS8: 8.nervener
- DASS11: 11.gettagit
- DASS12: 12.relax
- DASS14: 14.intol
- DASS18: 18.rattouch

**anxiety**

- DASS2: 2.drymth
- DASS4: 4.breatdiff
- DASS7: 7.tremb
- DASS9: 9.panfool
- DASS15: 15.panic
- DASS19: 19.heartphys
- DASS20: 20.scareas

**depression**

- DASS3: 3.posfeel
- DASS5: 5.init
- DASS10: 10.lookfor
- DASS13: 13.blue
- DASS16: 16.enthu
- DASS17: 17.worth
- DASS21: 21.meaning



**stress**

- DASS1: 1.wind
- DASS6: 6.ovreact
- DASS8: 8.nervener
- DASS11: 11.gettagit
- DASS12: 12.relax
- DASS14: 14.intol
- DASS18: 18.rattouch

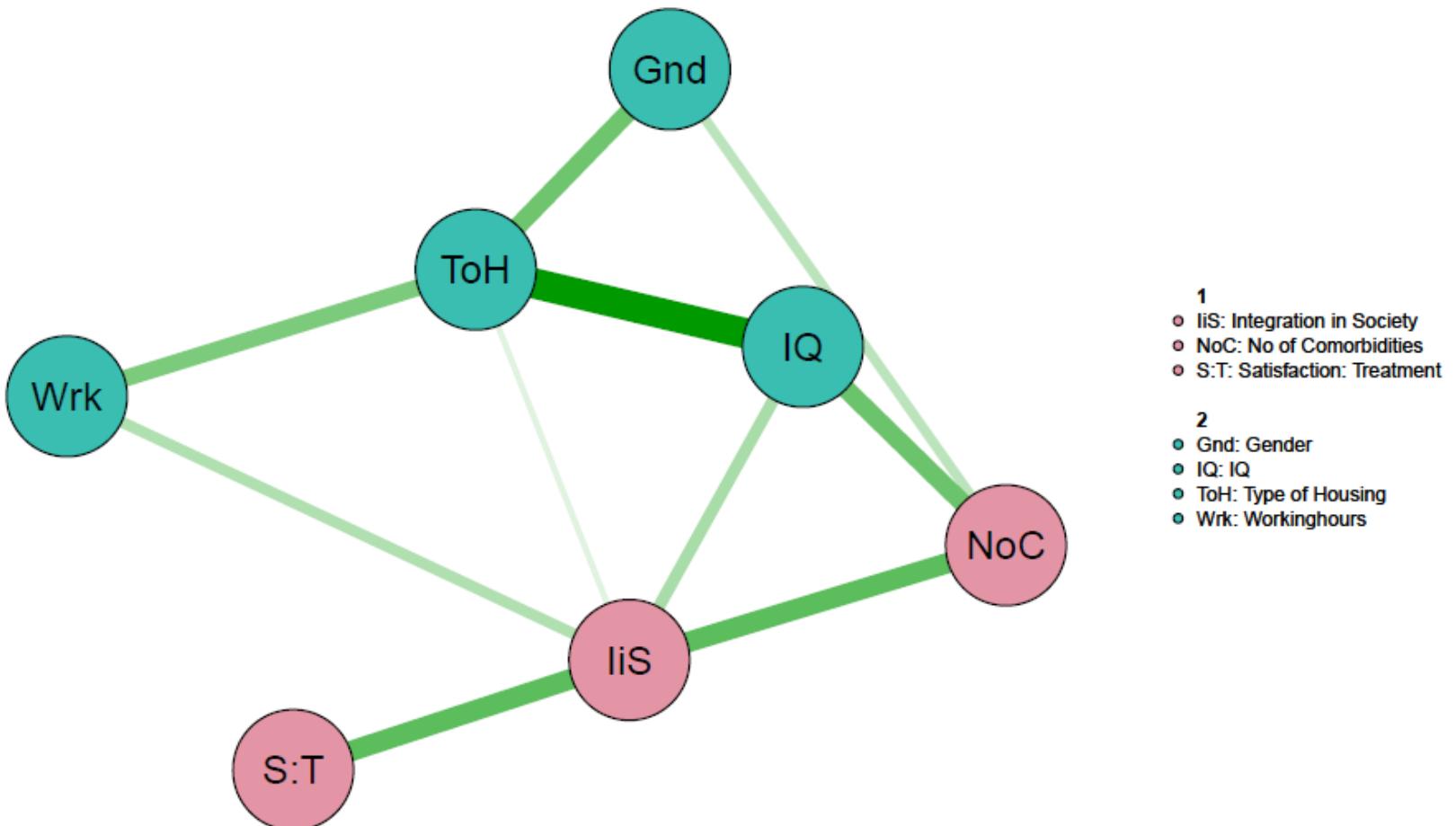
**anxiety**

- DASS2: 2.drymth
- DASS4: 4.breatdiff
- DASS7: 7.tremb
- DASS9: 9.panfool
- DASS15: 15.panic
- DASS19: 19.heartphys
- DASS20: 20.scareas

**depression**

- DASS3: 3.posfeel
- DASS5: 5.init
- DASS10: 10.lookfor
- DASS13: 13.blue
- DASS16: 16.enthu
- DASS17: 17.worth
- DASS21: 21.meaning

# Satisfação tratamento - autismo



# Comparação de redes

## Comparing network structures on three aspects: A permutation test

Working Paper · March 2017

DOI: 10.13140/RG.2.2.29455.38569

---

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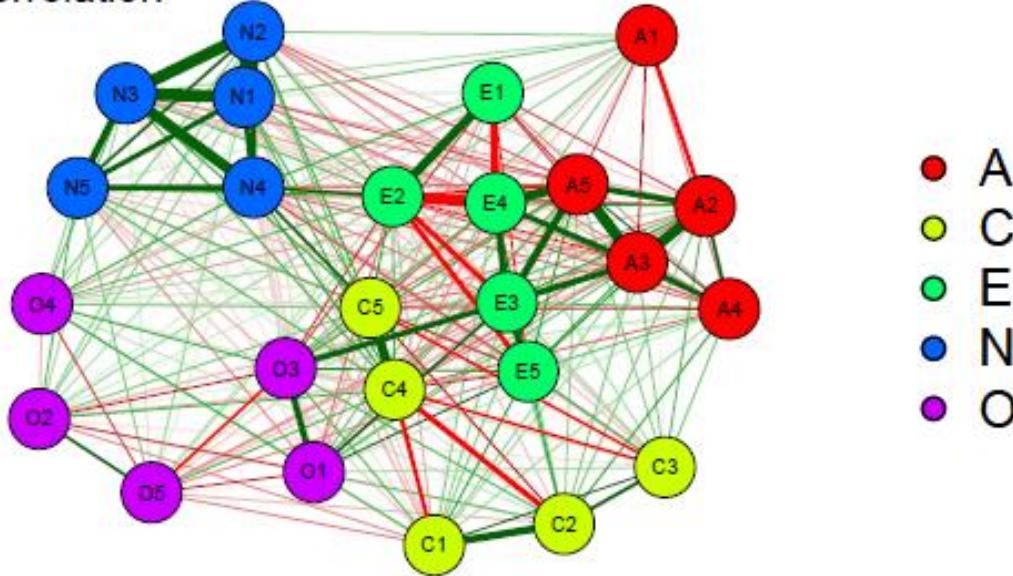
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University of Amsterdam

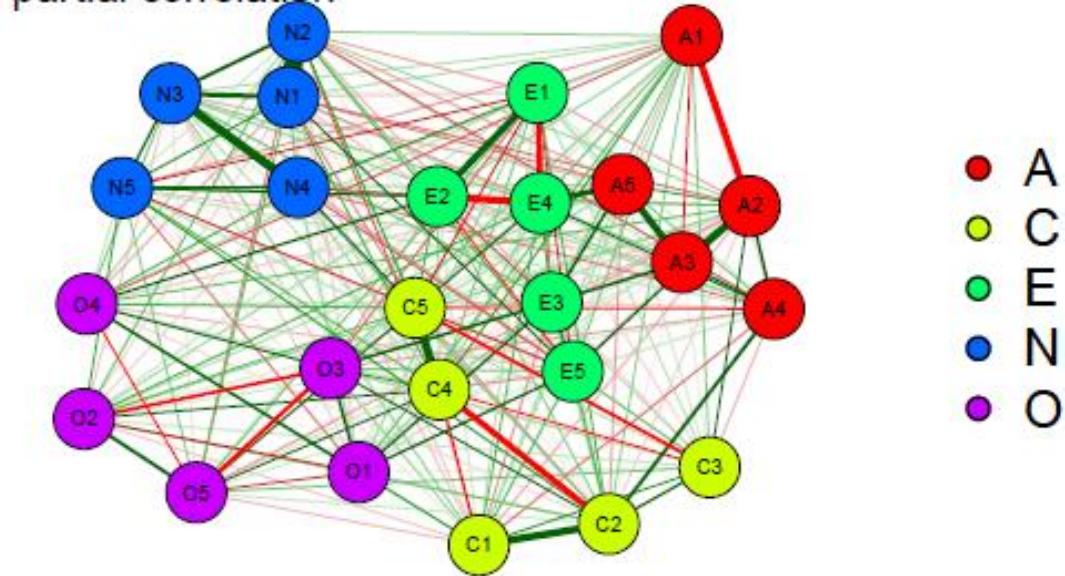
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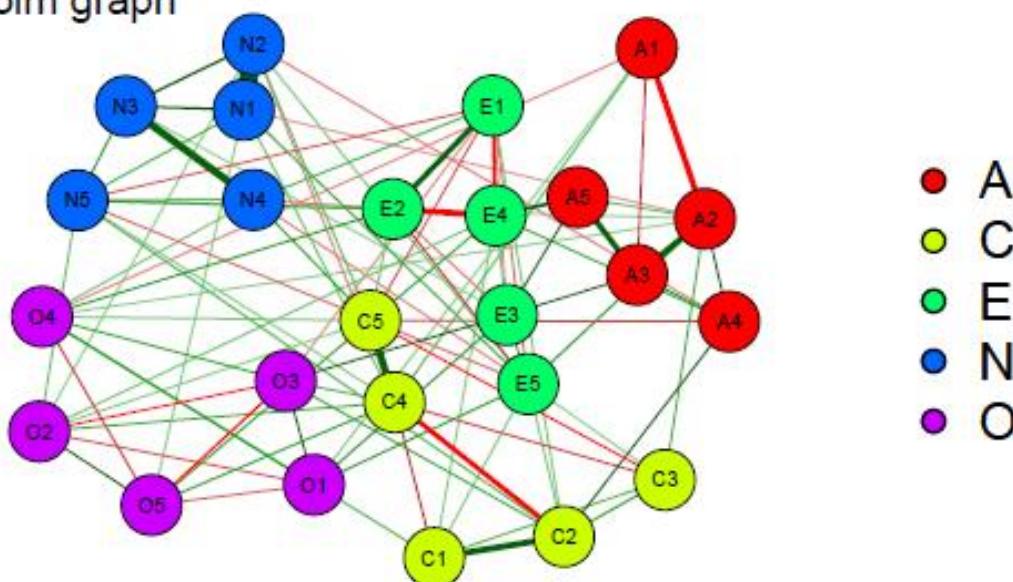
correlation



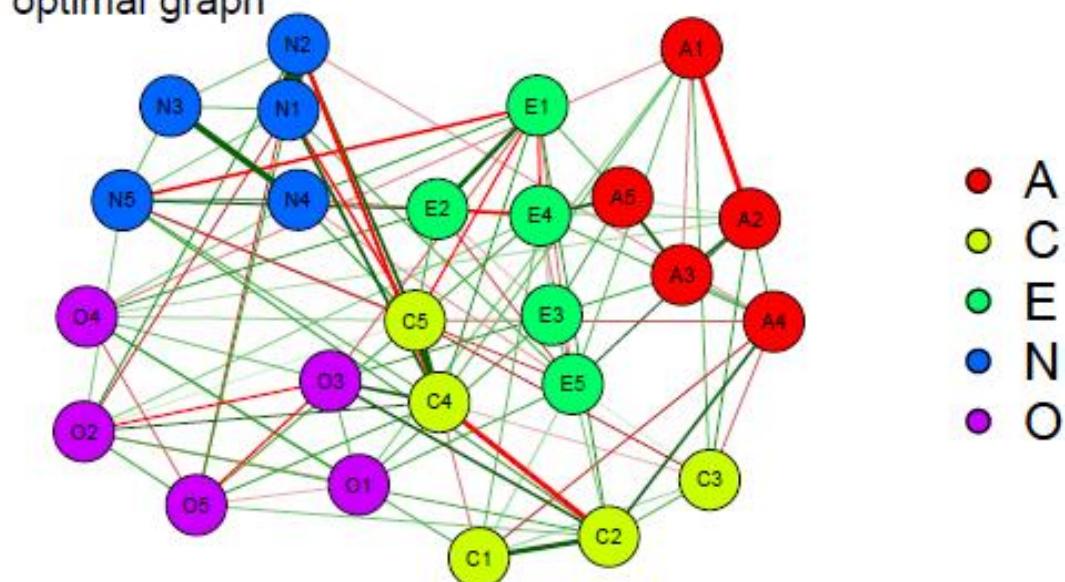
partial correlation



holm graph



optimal graph



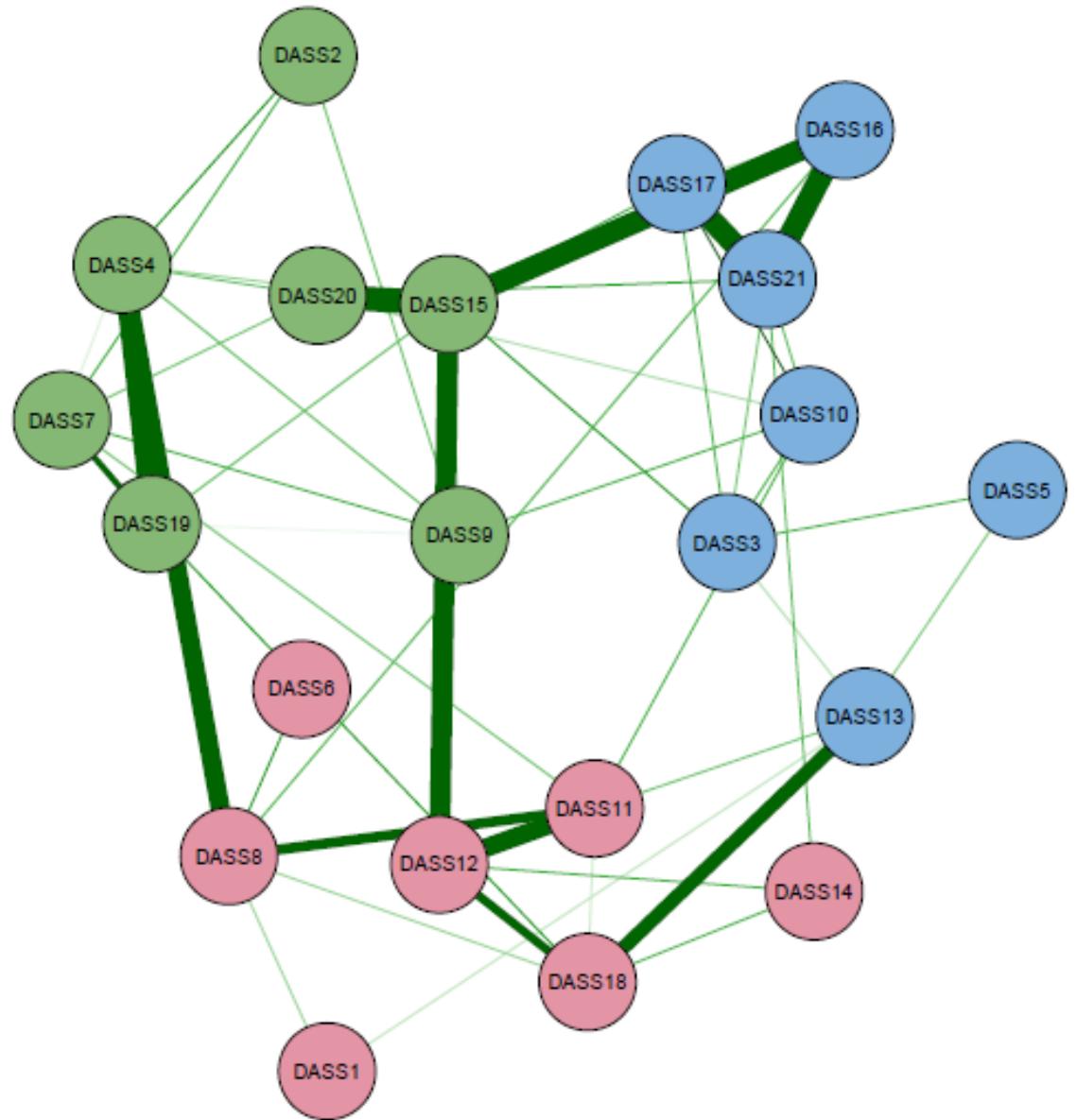
● A  
● C  
● E  
● N  
● O

● A  
● C  
● E  
● N  
● O

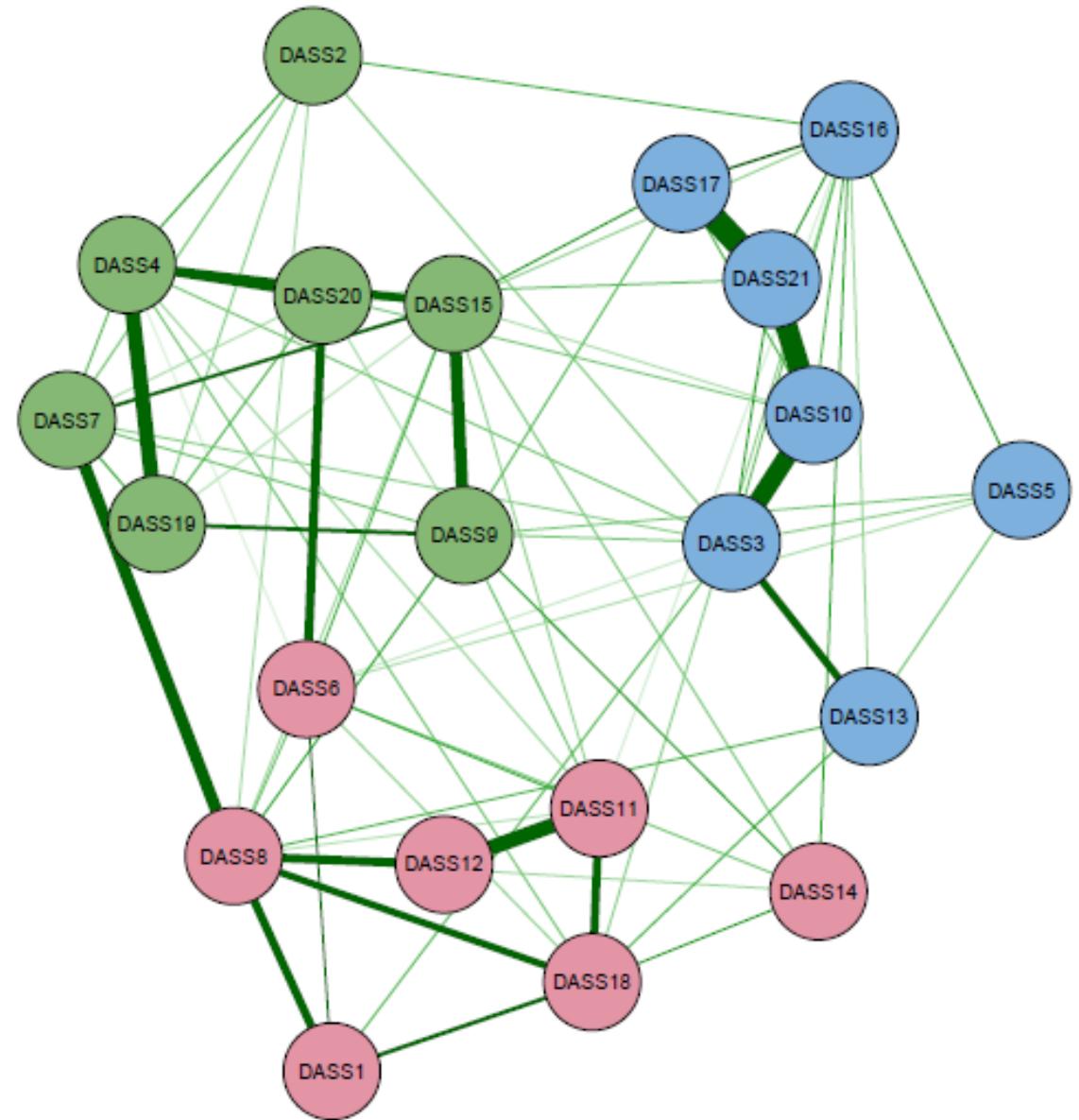
# DASS-21

- 175 homens
- 466 mulheres
- Variância estrutural – máxima diferença entre arestas
- Variância da força global – somatório em módulo da centralidade de força
- Variância de arestas – testa relações específicas par a par ou para todos os nodos

Masc



Fem

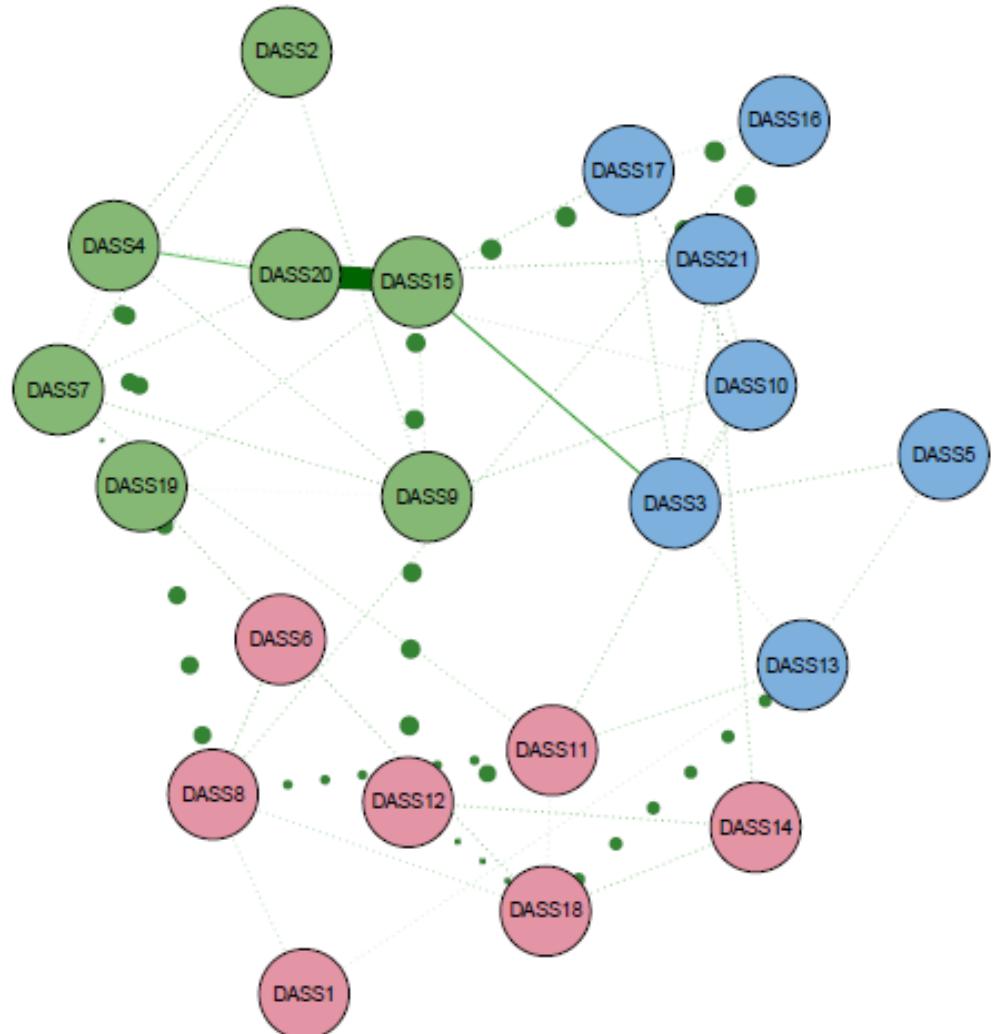


```
> dass_nct$nwinv.real  
[1] 1.413075  
> dass_nct$nwinv.perm  
[1] 1.750312 1.052788 1.591741 81.859487 1.089525  
[6] 1.578179 1.334670 1.237239 1.487468 1.357517  
> dass_nct$nwinv.pval  
[1] 0.5  
  
> dass_nct$glstrinv.sep  
[1] 45.50014 37.04170  
> dass_nct$glstrinv.real  
[1] 8.45844  
> dass_nct$glstrinv.perm  
[1] 11.266876 19.126481 15.865341 323.624139 17.840545  
[6] 4.235305 13.926695 23.694099 4.963055 15.847453  
> dass_nct$glstrinv.pval  
[1] 0.8  

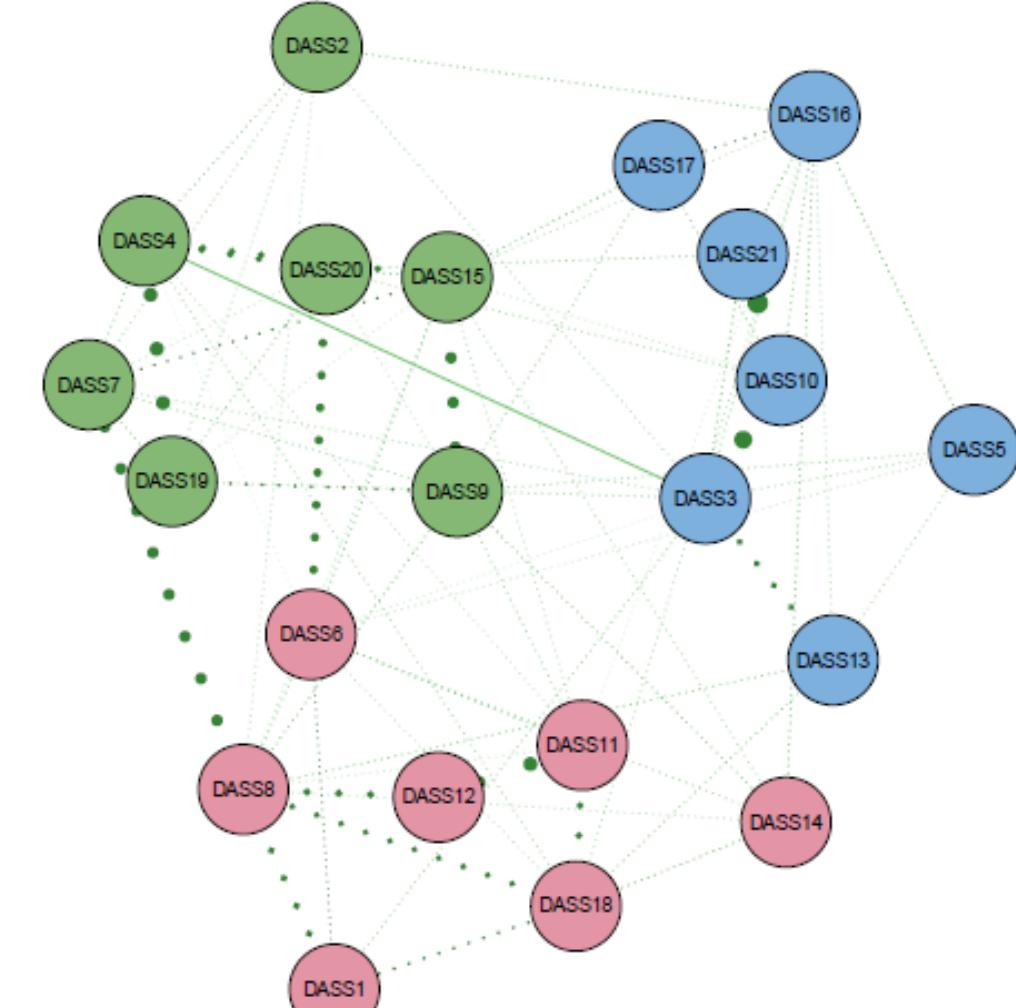
```

Aretas testadas – 3 e 4, 4 e 8

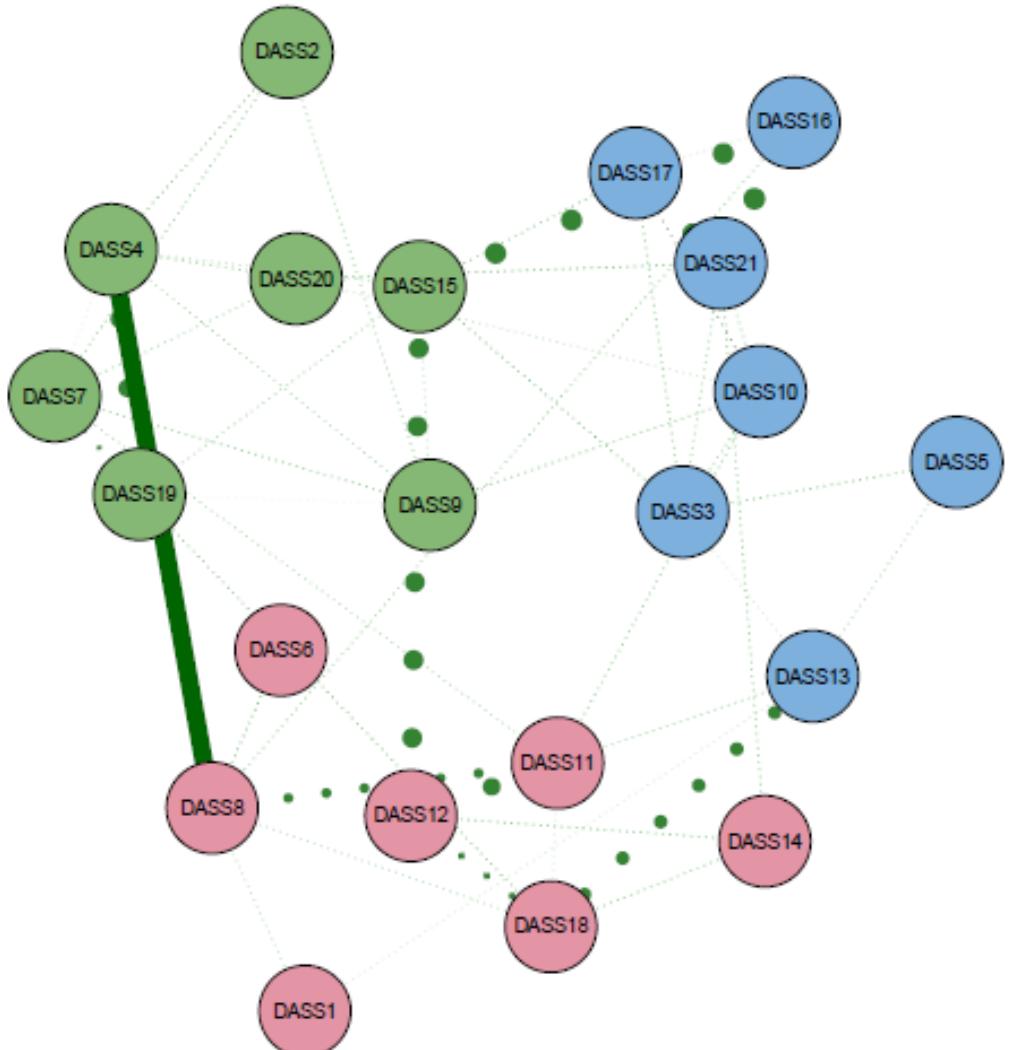
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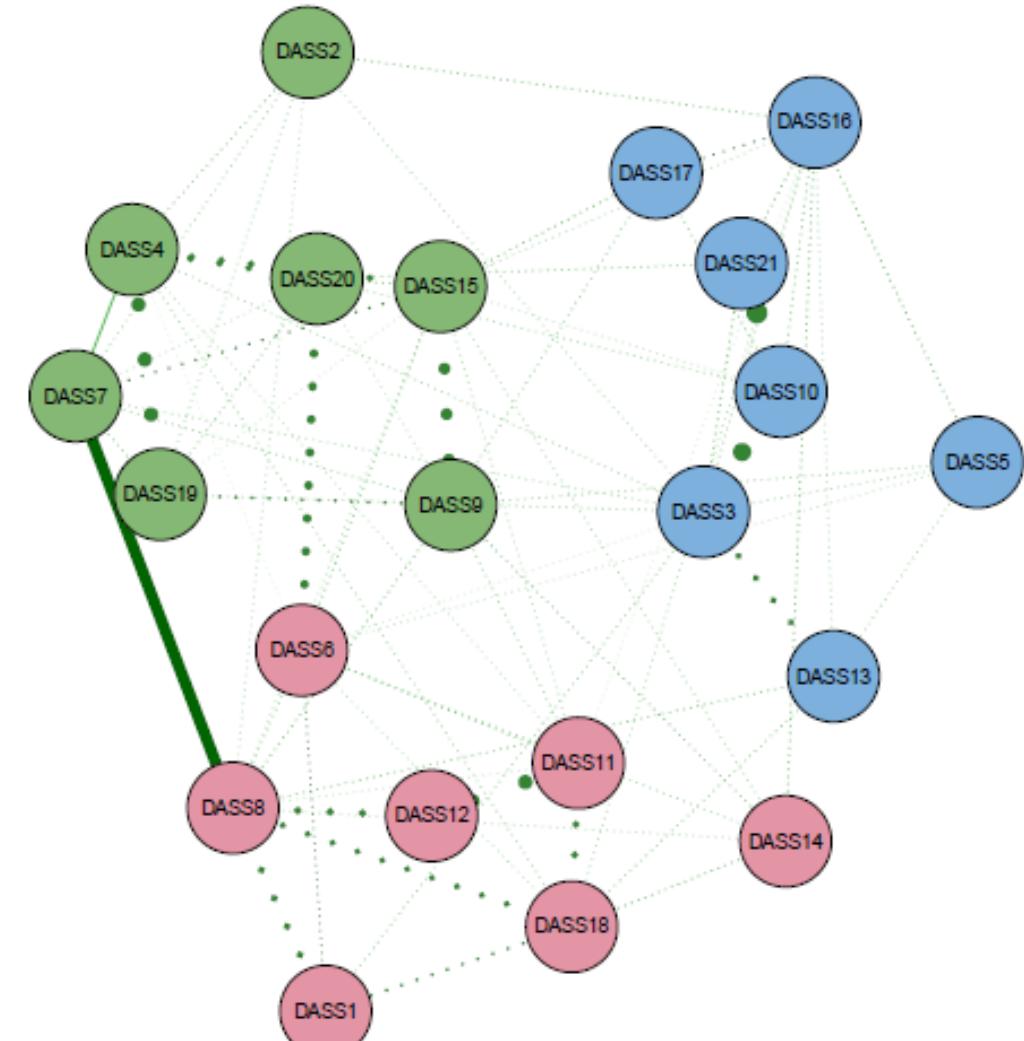
Fem



Masc



Fem



# Estabilidade da rede

Jan 2017

## Estimating Psychological Networks and their Accuracy: A Tutorial Paper

Sacha Epskamp, Denny Borsboom and Eiko I. Fried

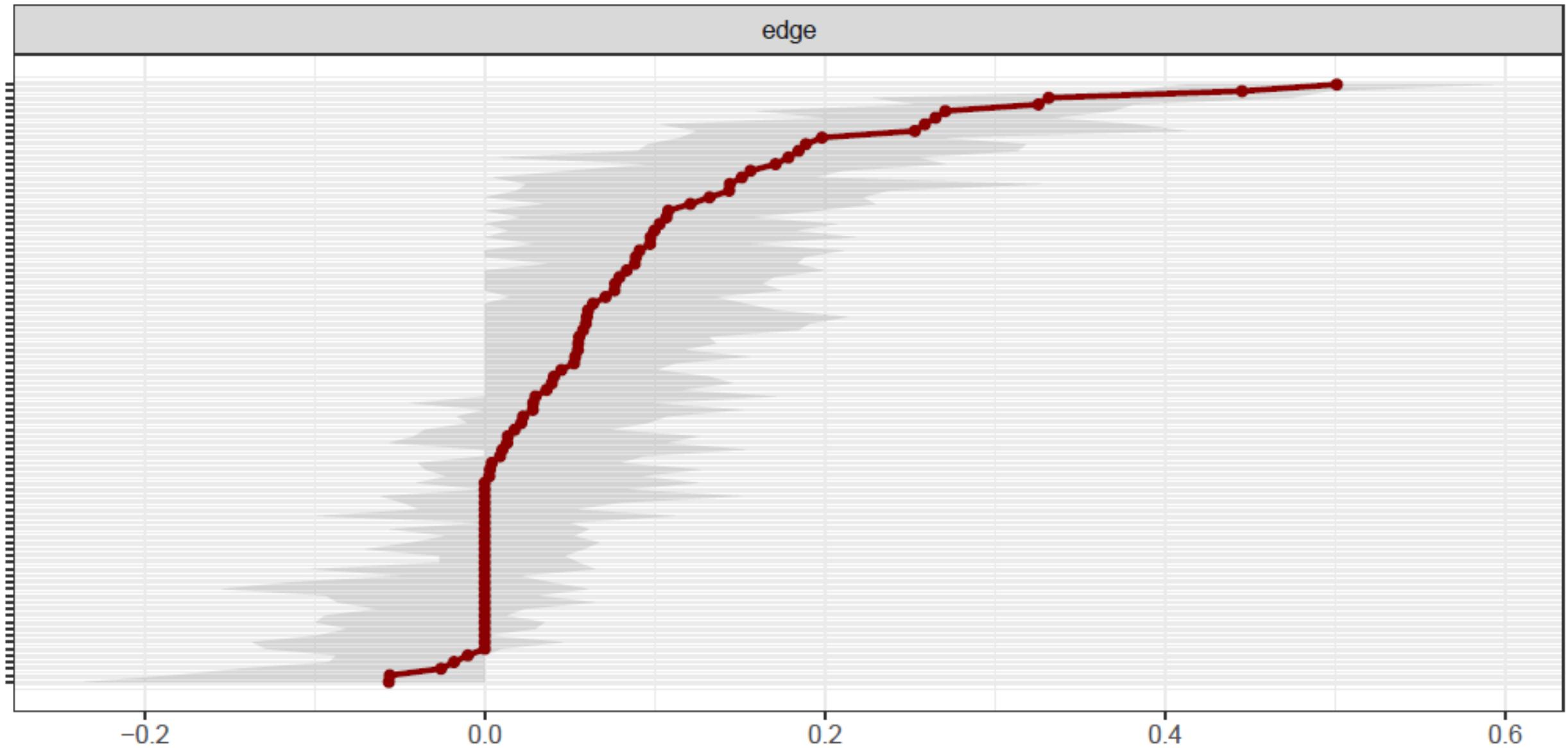
Department of Psychology, University of Amsterdam

### Abstract

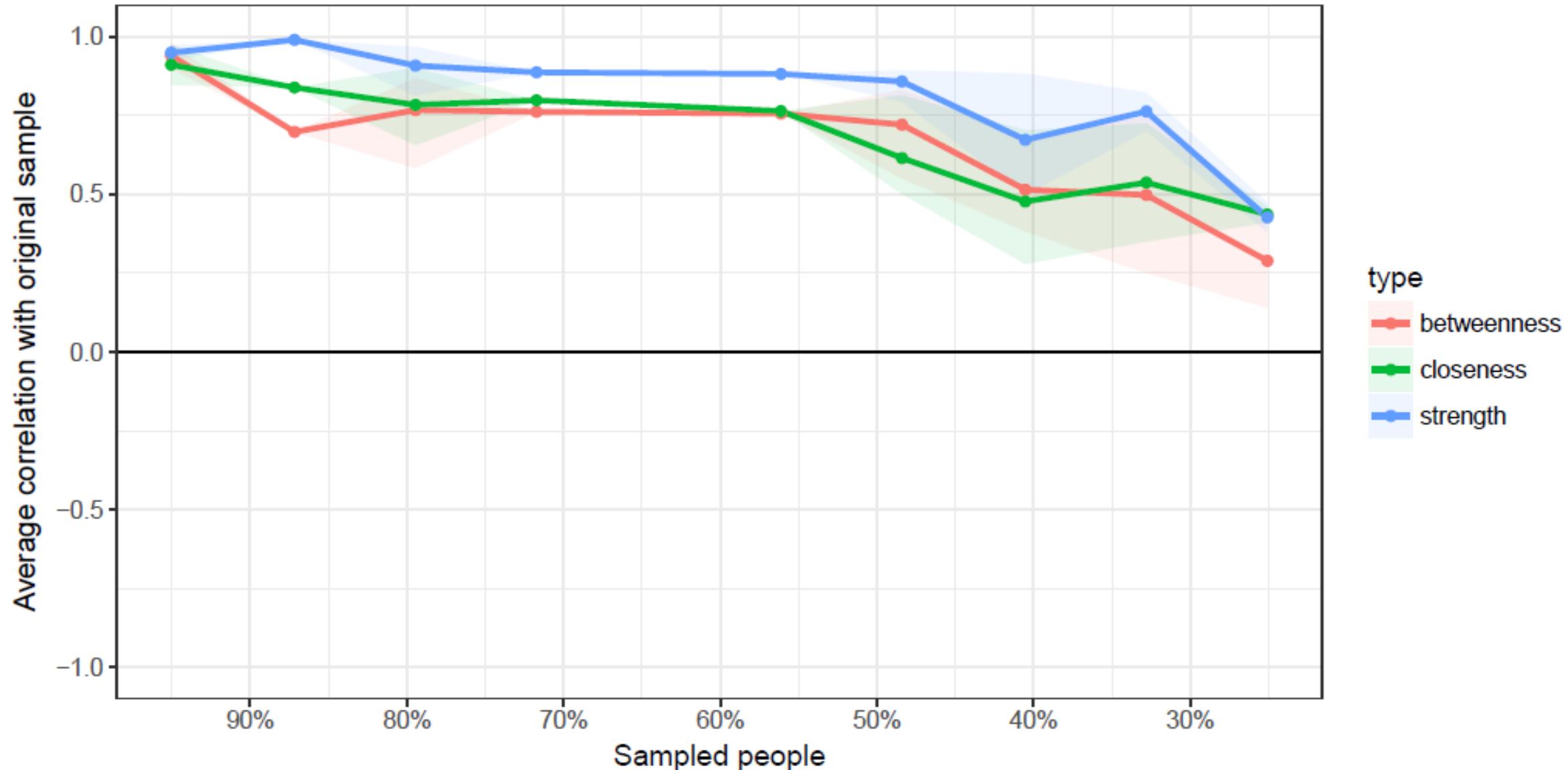
The usage of *psychological networks* that conceptualize behaviour as a complex interplay of psychological and other components has gained increasing popularity in various research fields. While prior publications have tackled the topics of estimating and interpreting such networks, little work has been

Estabilidade das arestas

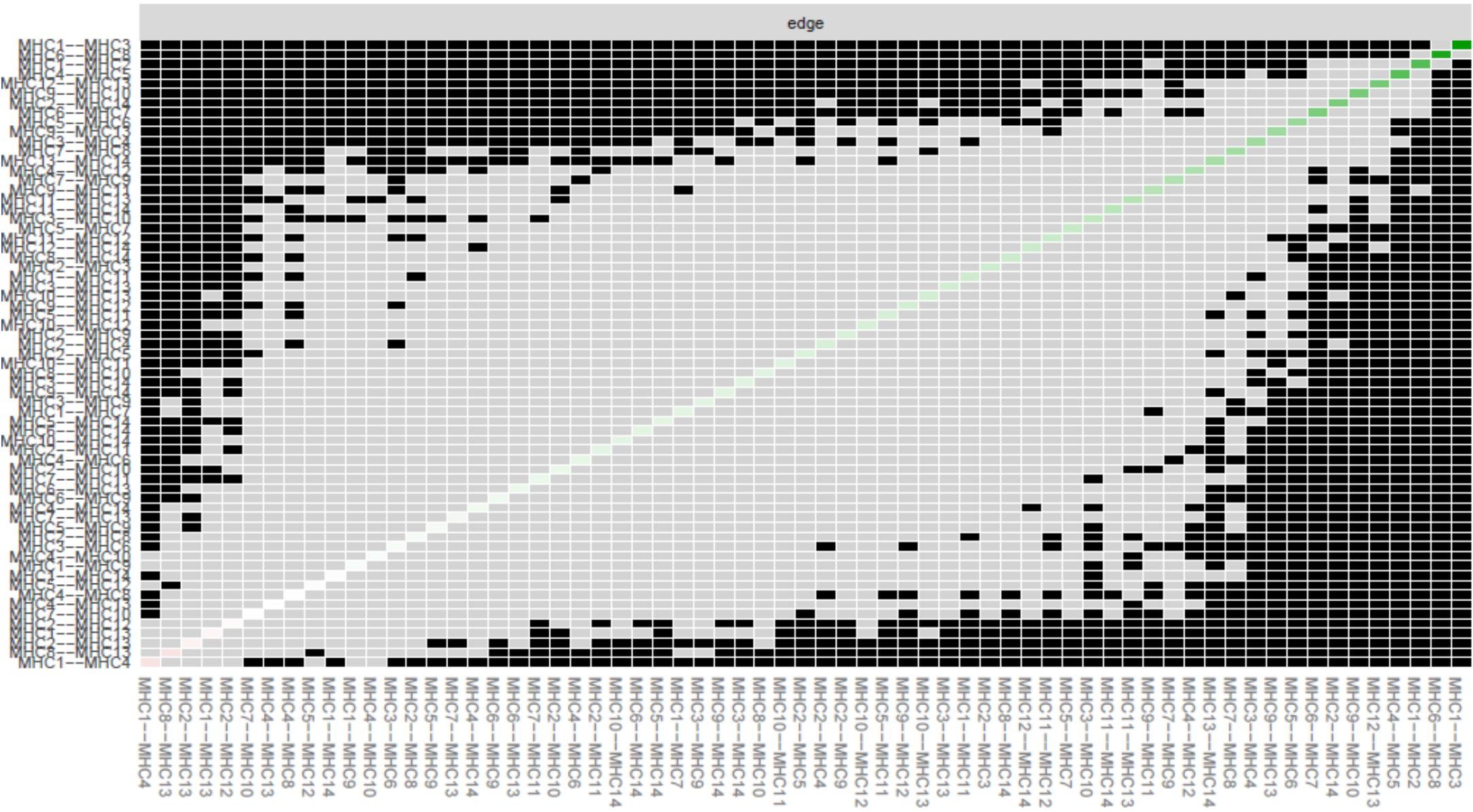
plot(boot1, labels = FALSE, order = "sample")



# Estabilidade das medidas de centralidade plot(boot2)



# Diferenças na força



Maximum drop proportions to retain correlation of 0.7 in at least 95% of the samples:

`betweenness`: 0.439

- For more accuracy, run `bootnet(..., caseMin = 0.283, caseMax = 0.516)`

`closeness`: 0.439

- For more accuracy, run `bootnet(..., caseMin = 0.283, caseMax = 0.516)`

`strength`: 0.672

- For more accuracy, run `bootnet(..., caseMin = 0.595, caseMax = 0.749)`

# Teste de diferença entre medidas de centralidade

```
Expected significance level given number of bootstrap samples is approximately: 0.092
  id1  id2  measure      lower      upper significant
1 MHC3 MHC14 strength -0.5700955 0.1914356       FALSE
```

# Predição de vértices em uma rede



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## Predictability in Network Models

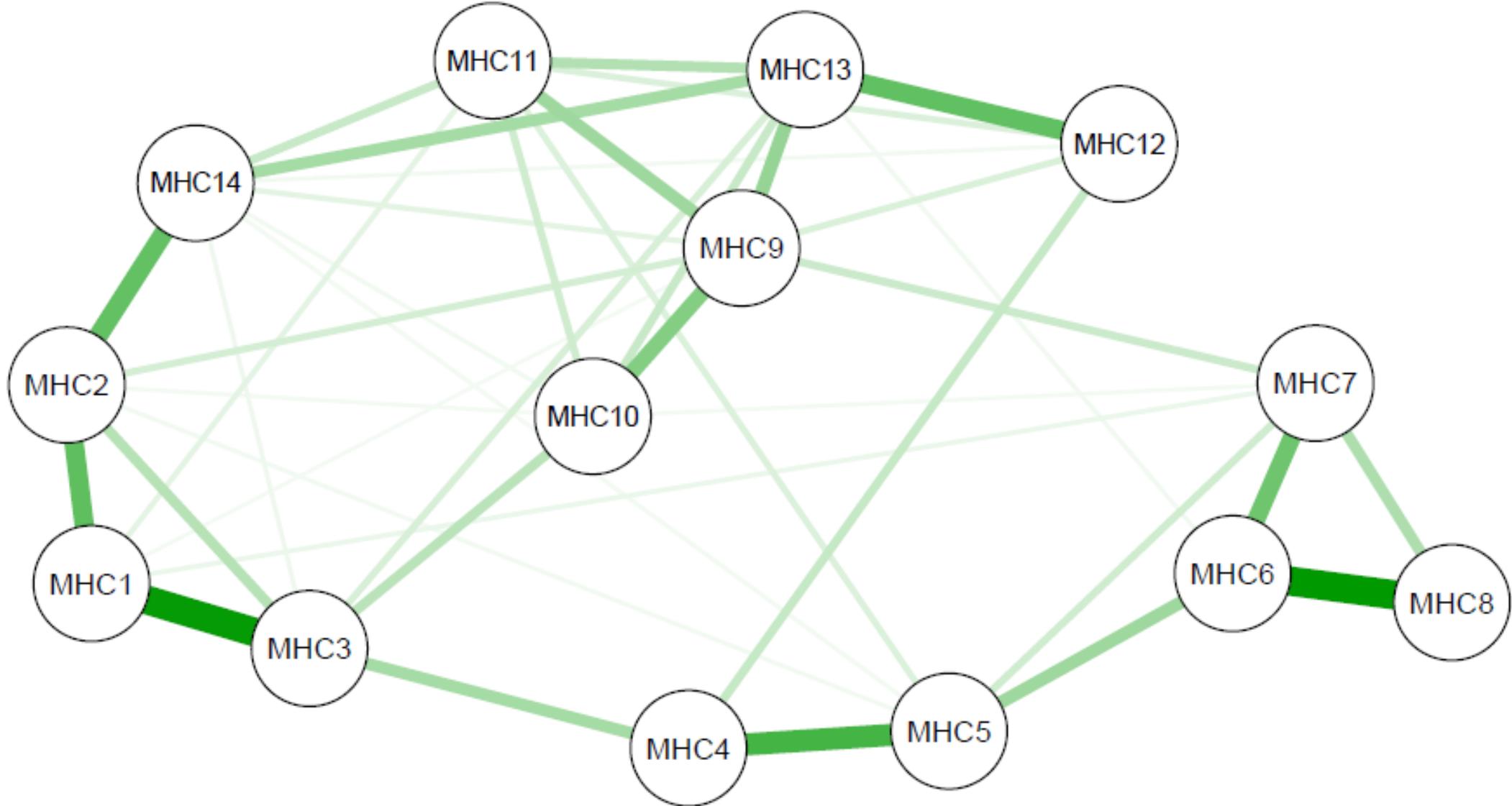
October 31, 2016

By Jonas Haslbeck - r

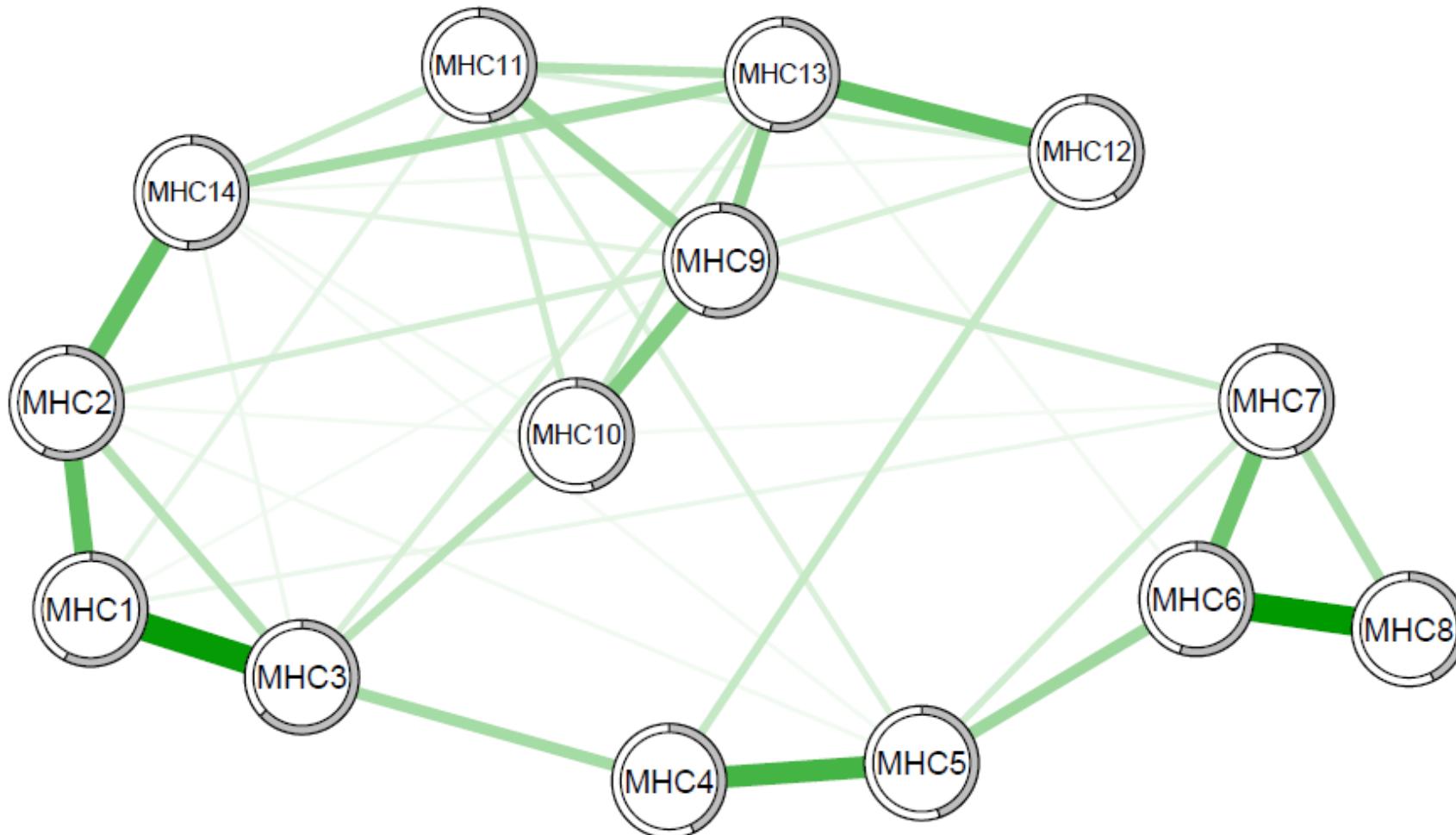
```
> pred_mhc<-predict(fit_mhc,mhc,error.continuous = "VarExpl")
> pred_mhc$error
   Variable Error ErrorType
1      MHC1 0.577  VarExpl
2      MHC2 0.570  VarExpl
3      MHC3 0.631  VarExpl
4      MHC4 0.428  VarExpl
5      MHC5 0.448  VarExpl
6      MHC6 0.548  VarExpl
7      MHC7 0.441  VarExpl
8      MHC8 0.428  VarExpl
9      MHC9 0.551  VarExpl
10     MHC10 0.451  VarExpl
11     MHC11 0.468  VarExpl
12     MHC12 0.408  VarExpl
13     MHC13 0.534  VarExpl
14     MHC14 0.511  VarExpl
```

(This article was first published on [Jonas Haslbeck - r](#), and kindly contributed to R-bloggers)

```
fit_mhc<-mgmfit(mhc,type = rep("g",p),lev=rep(1,p),rule.reg = "OR")
qgraph(fit_mhc$wadj,layout="spring",labels=colnames(mhc))
```



```
mean(pred_mhc$error>Error) [1] 0.4995714
```



# Modelos de rede de variáveis latentes



[Psychometrika](#)

pp 1–24

## Generalized Network Psychometrics: Combining Network and Latent Variable Models

Authors

[Authors and affiliations](#)

Sacha Epskamp , Mijke Rhemtulla, Denny Borsboom

Article

First Online: 13 March 2017

DOI: [10.1007/s11336-017-9557-x](https://doi.org/10.1007/s11336-017-9557-x)

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[doi:10.1007/s11336-017-9557-x](https://doi.org/10.1007/s11336-017-9557-x)

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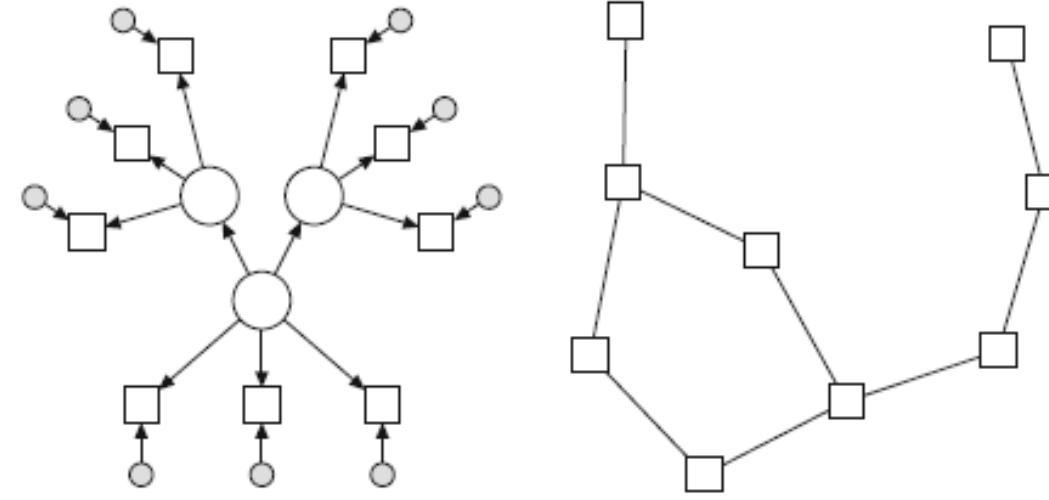
GENERALIZED NETWORK PSYCHOMETRICS: COMBINING NETWORK AND LATENT VARIABLE MODELS

SACHA EPSKAMP, MIJKE RHEMTULLA AND DENNY BORSBOOM

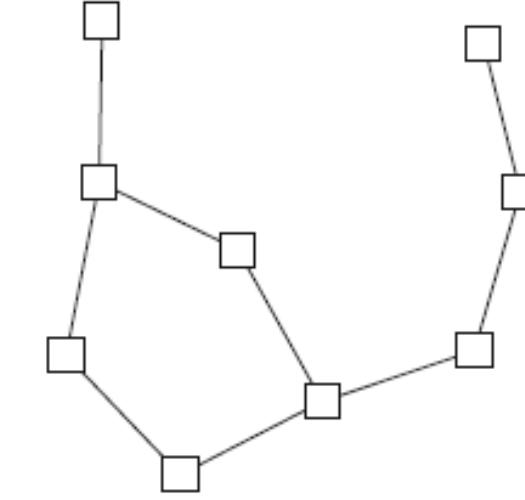
UNIVERSITY OF AMSTERDAM

# Casos especiais de SEM

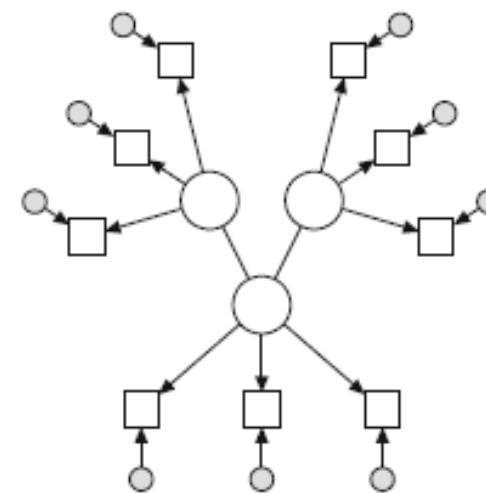
- a) SEM
- b) Network
- c) Latent Network
- d) Residual Network



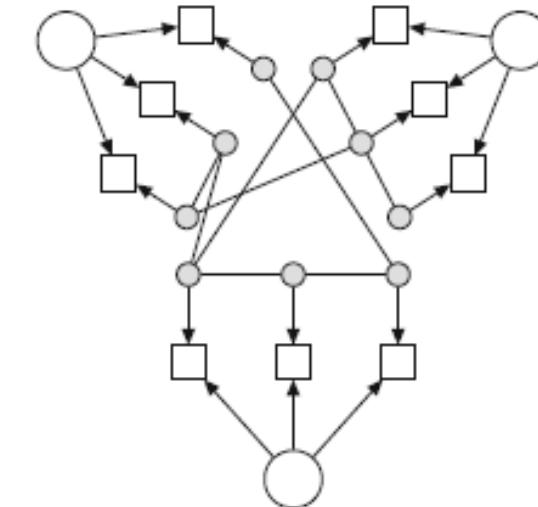
(a)



(b)

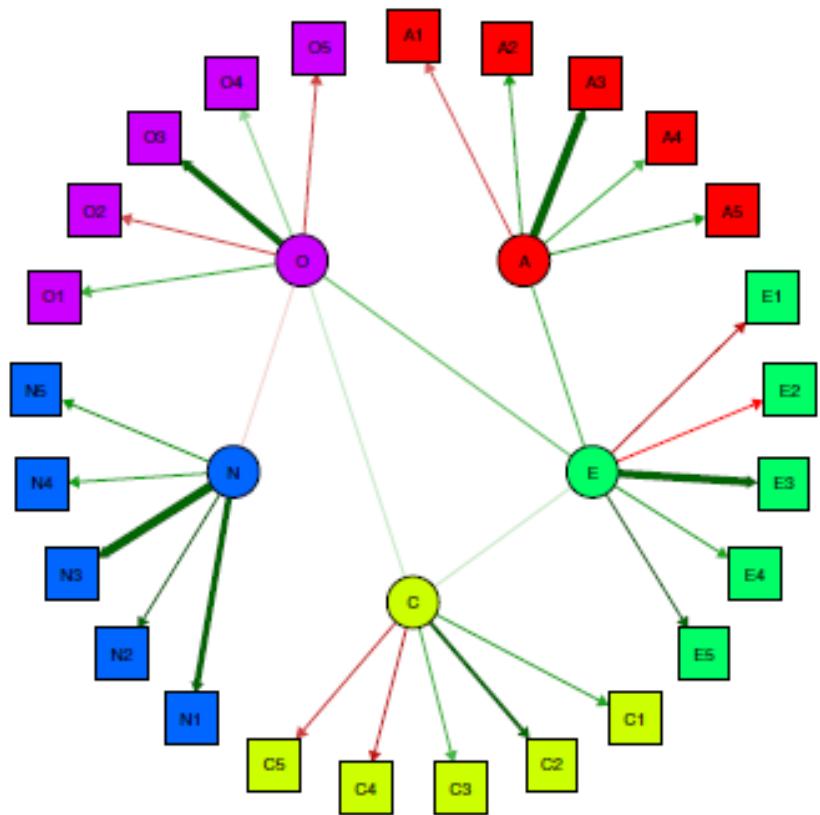


(c)

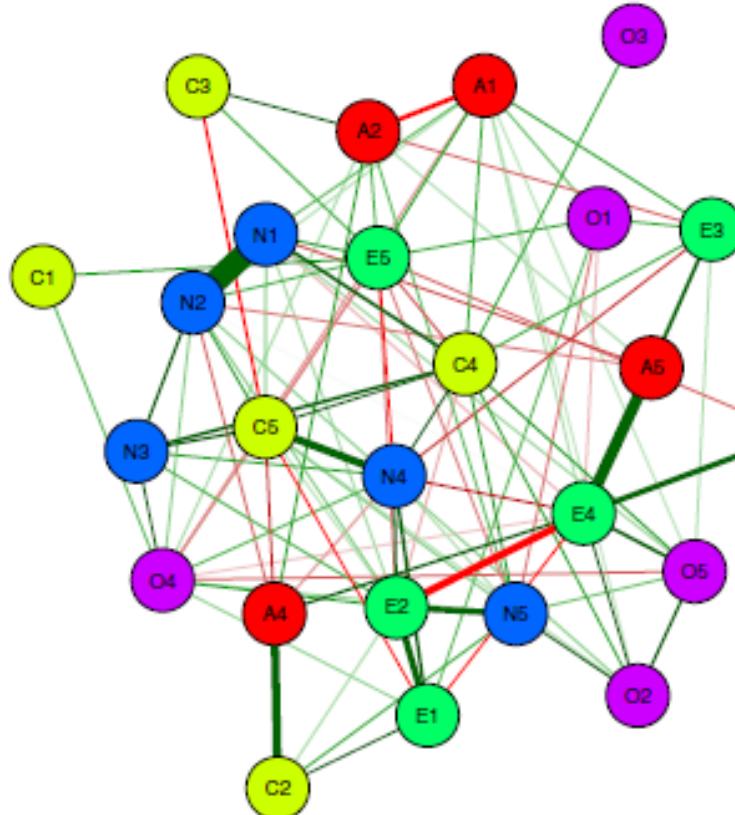


(d)

## Factor structure & latent network



## Residual network



### Agreeableness

- A1: Am indifferent to the feelings of others.
- A2: Inquire about others' well-being.
- A3: Know how to comfort others.
- A4: Love children.
- A5: Make people feel at ease.

### Conscientiousness

- C1: Am exacting in my work.
- C2: Continue until everything is perfect.
- C3: Do things according to a plan.
- C4: Do things in a half-way manner.
- C5: Waste my time.

### Extraversion

- E1: Don't talk a lot.
- E2: Find it difficult to approach others.
- E3: Know how to captivate people.
- E4: Make friends easily.
- E5: Take charge.

### Neuroticism

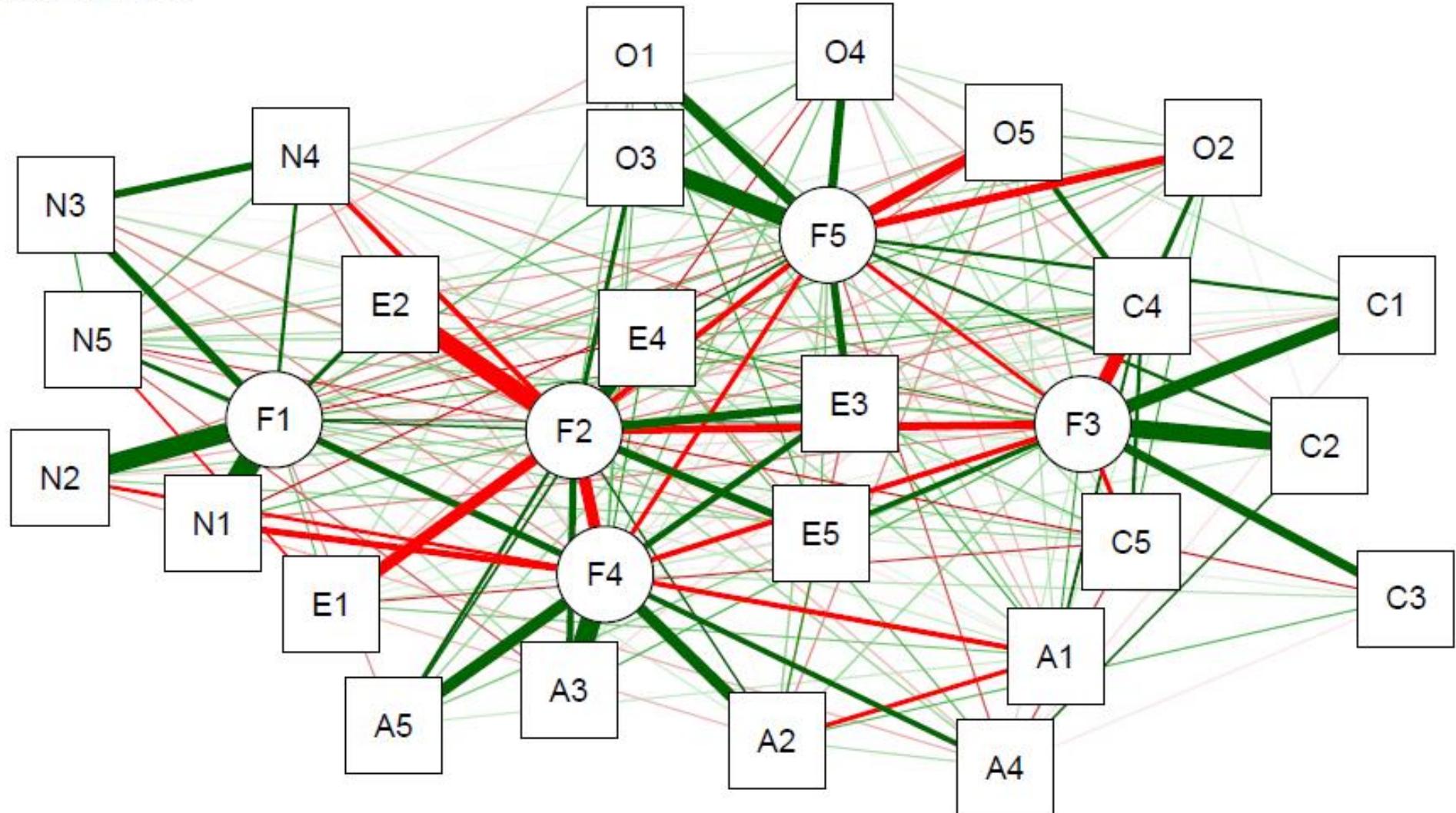
- N1: Get angry easily.
- N2: Get irritated easily.
- N3: Have frequent mood swings.
- N4: Often feel blue.
- N5: Panic easily.

### Openness

- O1: Am full of ideas.
- O2: Avoid difficult reading material.
- O3: Carry the conversation to a higher level.
- O4: Spend time reflecting on things.
- O5: Will not probe deeply into a subject.

```
bfi_lvnet<-EBICvglasso(bfi2_cors,nrow(bfi2),5,gamma = 0.25,nRho =  
100)  
plot(bfi_lvnet,"network")
```

Estimated network



# Índices de ajuste

	Measure	value
1	nvar	30
2	nobs	465
3	npar	228
4	df	237
5	fmin	0
6	chisq	0
7	pvalue	1
8	baseline.chisq	48138.85
9	baseline.df	435
10	baseline.pvalue	0
11	nfi	1
12	tli	1.01
13	rfi	1
14	ifi	1.00
15	rni	1.00
16	cfi	1
17	rmsea	0
18	rmsea.ci.lower	0
19	rmsea.ci.upper	0
20	rmsea.pvalue	1
21	rmr	< 0.0001
22	srmr	< 0.0001
23	logl	-94005.69
24	unrestricted.logl	-94005.69
25	aic	188467.39
26	bic	189821.11
27	bic2	189096.67
28	ebic	191630.83
29	ebictuning	0.25

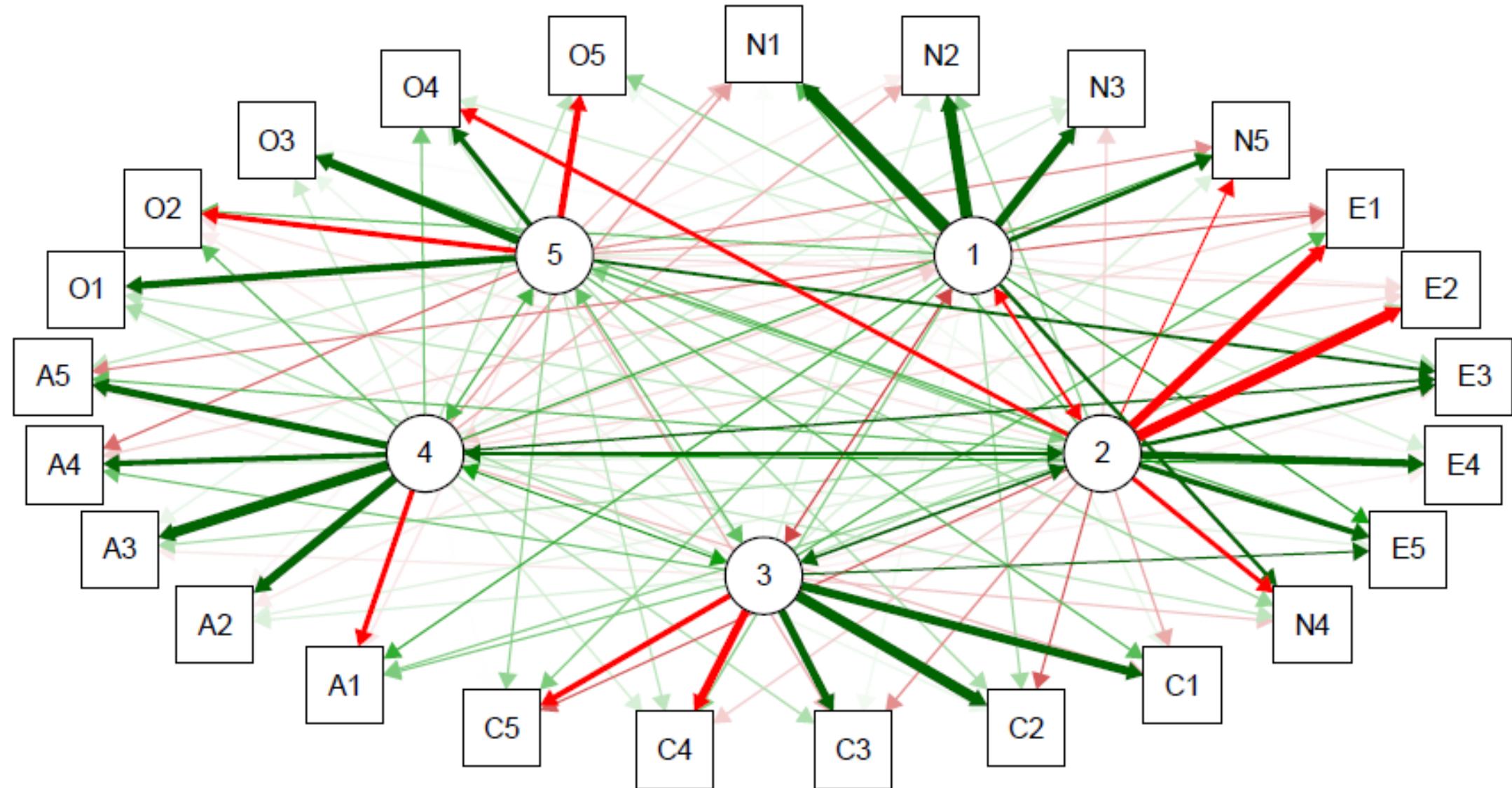
```
bfiWadj<-getWmat(bfi_lvg)  
View(bfiWadj[c(26:30),c(26:30)])
```

F1 = Neuroticismo F2 = Extroversão F3 = Conscienciosidade  
F4 = Socialização F5 = Abertura

	F1	F2	F3	F4	F5
F1	0.00000000	0.1244263	0.1205141	0.2267282	0.07252484
F2	0.12442635	0.0000000	-0.2528330	-0.3444721	-0.20192992
F3	0.12051407	-0.2528330	0.0000000	-0.1962215	-0.16164798
F4	0.22672816	-0.3444721	-0.1962215	0.0000000	-0.17756079
F5	0.07252484	-0.2019299	-0.1616480	-0.1775608	0.00000000

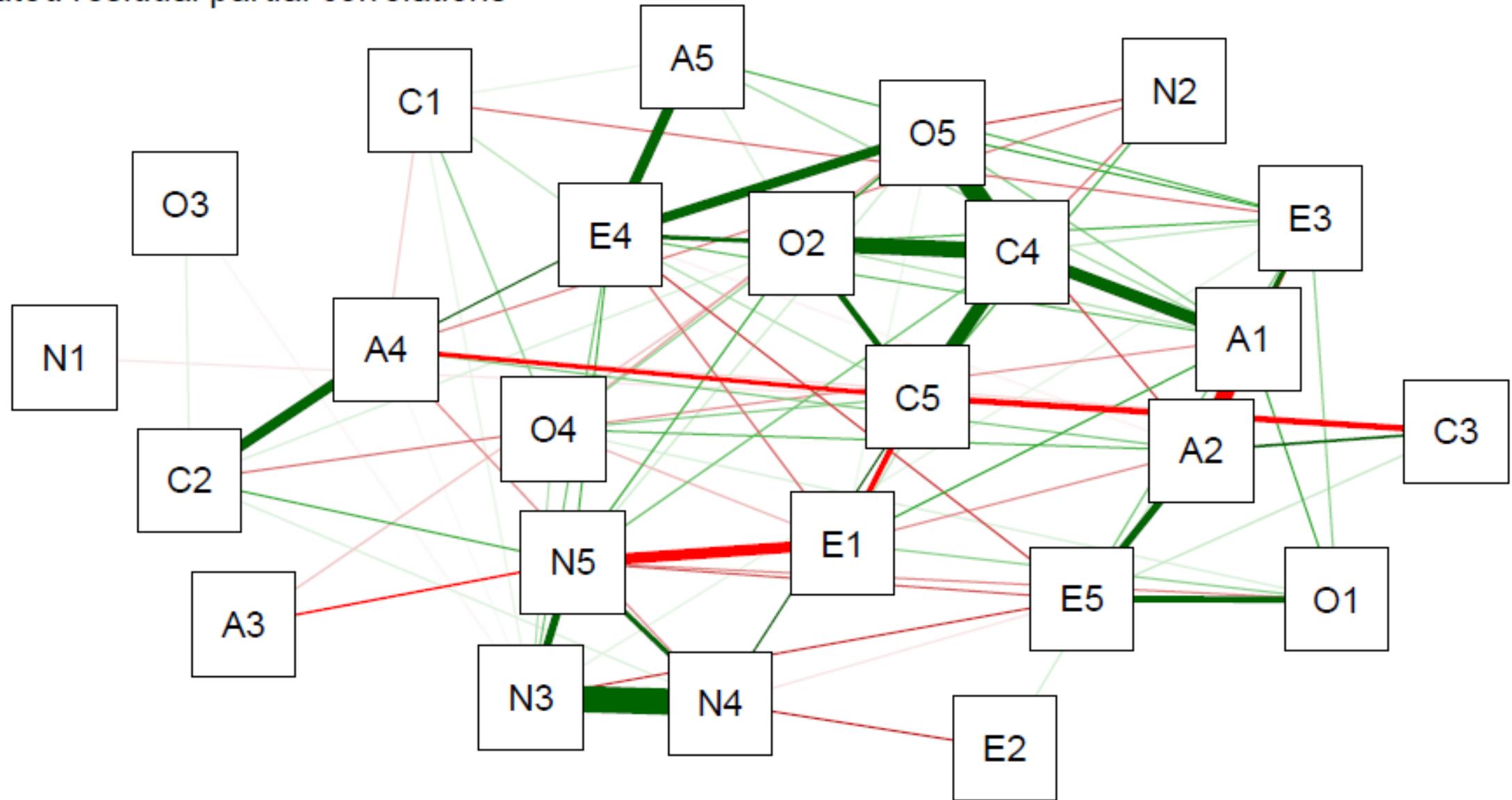
plot(bfi\_lvnet,"loadings")

Estimated factor loadings



```
plot(bfi_lvnet,"residpcors")
```

Estimated residual partial correlations



# Aspectos não contemplados

- Redes temporais (VAR)
- N=1 networks
- Redes direcionais (causais), redes bayesianas
- Etc...

# #FORA #TEMER

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Claudio Angelo

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Elizabeth Gibney

30 September 2015

# Agradecimentos

- Hudson Golino
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- João Vissoci
- Claudio Hutz, Denise Bandeira e Clarissa Trentini
- Sônia Enumo e Solange Wechsler

# OBRIGADO!!!

Análise de rede: uma introdução  
e aplicações na psicologia

Prof. Dr. Wagner de Lara Machado

wagner.machado@puc-campinas.edu.br