

University of Groningen

Symptom network models in depression research

van Borkulo, Claudia

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version

Publisher's PDF, also known as Version of record

Publication date:
2018

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

van Borkulo, C. D. (2018). Symptom network models in depression research: From methodological exploration to clinical application [Groningen]: University of Groningen

Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

The studies presented in this thesis were funded by GGZ Friesland.

Publication of this dissertation was partially supported by the University Medical Center Groningen, the University of Groningen, and the Graduate School SHARE of the University Medical Center Groningen.

ISBN: 978-94-034-0379-3 (printed version)

ISBN: 978-94-034-0378-6 (digital version)

On the cover: Tijmen Stuijt — illustrated by Famke Stuijt

Cover design, layout design and printed by:  Lovebird Design.
www.lovebird-design.com

Paranymphs: Angélique O. J. Cramer and Laura F. Bringmann

©2017, Claudia D. van Borkulo

No parts of this thesis may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording or any information storage and retrieval system, without permission of the author.

Symptom network models in depression research

From methodological exploration to clinical application

PhD thesis

to obtain the degree of PhD at the
University of Groningen
on the authority of the
Rector Magnificus Prof. dr. E. Sterken
and in accordance with
the decision by the College of Deans.

This thesis will be defended in public on

Wednesday, January 17 2018 at 12.45 hours

by

Claudia Debora van Borkulo

born on March 16 1971
in Amsterdam

Supervisors

Prof. R.A. Schoevers
Prof. D. Borsboom

Co-supervisors

Dr. L. Boschloo
Dr. L. J. Waldorp

Assessment committee

Prof. I.M. Engelhard
Prof. A.J. Oldehinkel
Prof. M.E. Timmerman

Voor Famke en Tijmen

TABLE OF CONTENTS

	Page
1 Introduction	1
1.1 The network perspective on psychopathology	2
1.2 This thesis	2
1.2.1 A theoretical deepening of the network perspective on psychopathology	3
1.2.2 Methodological challenges for group-level analyses: network estimation and comparison	4
1.2.3 Clinical studies relating vulnerability to local and global connectivity of group-level networks	4
1.2.4 Methodological challenges at the level of the individual: using network models to predict clinical course in patients with depression	5
1.2.5 Conclusions	5
2 The network approach	7
2.1 Mental disorders as complex dynamical systems	8
2.2 Constructing Networks	11
2.2.1 Graphical models	11
2.2.2 Gaussian data	14
2.2.3 Binary data	22
2.2.4 An oracle algorithm to identify connections	25
2.2.5 Longitudinal data	27
2.3 Network Analysis	32
2.3.1 Centrality measures	32

2.3.2	Predicting dynamics over time	35
2.3.3	Network comparison	36
2.4	Current state-of-the-art	38
2.4.1	Comorbidity	39
2.4.2	Early-warning signals	40
2.4.3	Higher connectivity, more problems	43
2.5	Discussion	44
3	Major depressive disorder as a Complex Dynamic System	49
3.1	Introduction	50
3.1.1	What is MDD as a complex dynamic system?	51
3.1.2	Aim of this paper	52
3.1.3	Vulnerability in the MDD dynamic system	52
3.2	Simulation I: Investigating the vulnerability hypothesis	54
3.2.1	Methods	56
3.2.2	Results and discussion	59
3.3	Simulation II: Investigating the influence of external stress	61
3.3.1	Methods	65
3.3.2	Results and discussion of Simulation II	67
3.4	Discussion	71
4	A new method for constructing networks from binary data	75
4.1	Introduction	76
4.2	Methods	80
4.2.1	eLasso	80
4.2.2	Validation study	83
4.2.3	Data description	84
4.3	Results	85
4.3.1	Validation study	85
4.3.2	Application to real data	88
4.4	Discussion	91
5	Comparing network structures on three aspects: A permutation test	97
5.1	Introduction	98
5.2	Network Comparison Test	100
5.2.1	Network estimation	100

5.2.2	Test statistics	102
5.2.3	Procedure	103
5.2.4	Power of NCT	104
5.3	Simulation study	106
5.3.1	Setup of simulation study	106
5.3.2	Results	108
5.3.3	Application to real data	111
5.3.4	Real data	112
5.3.5	Results	112
5.4	Discussion	113
6	Association of symptom network structure with the course of depression	117
6.1	Introduction	119
6.2	Methods	121
6.2.1	Study Sample	121
6.2.2	Persistence of MDD at Follow-up	121
6.2.3	Baseline <i>DSM-IV</i> Symptoms of MDD	122
6.2.4	Statistical Analysis	122
6.3	Results	125
6.3.1	General Differences	125
6.3.2	Differences in Overall Connectivity	126
6.3.3	Differences in Local Connectivity	126
6.4	Discussion	128
7	Between- versus within-subjects analysis	131
7.1	Summary of comment	132
7.2	Reply	132
8	A prospective study on how symptoms in a network predict the onset of depression	135
8.1	The network approach	136
8.2	Aim of this study	136
8.3	Results	137
8.4	Conclusion	137

9 The contact process as a model for predicting network dynamics of psychopathology	141
9.1 Introduction	142
9.2 Model specification	147
9.3 Estimation procedures	150
9.3.1 Percolation Indicator estimation	151
9.3.2 Network estimation	153
9.4 Validation study	154
9.4.1 Design	154
9.4.2 Results validation study	156
9.5 Application of method to real data	158
9.5.1 Discrepancy between model and real data	158
9.5.2 Description of real data	159
9.5.3 Results of application to real data	159
9.6 Discussion	163
10 Mental disorders as networks of problems: A review of recent insights	169
10.1 Introduction	170
10.2 Comorbidity	172
10.2.1 Comorbidity from a network perspective	172
10.2.2 Comorbidity in empirical data	172
10.3 Prediction	175
10.3.1 Early warning signals	175
10.3.2 Prediction via network characteristics	177
10.4 Clinical intervention	178
10.4.1 The concept of centrality	178
10.4.2 What are good symptoms for clinical intervention?	179
10.5 Future directions	181
10.5.1 Clinical research	181
10.5.2 Methodological research	183
10.6 Summary	184
11 Discussion	187
11.1 This thesis	187

11.1.1	A theoretical deepening of the network perspective on psychopathology	187
11.1.2	Methodological challenges for group-level analyses: network estimation and comparison	188
11.1.3	Empirical studies relating local and global connectivity to vulnerability	189
11.1.4	Methodological challenge for individuals: predicting future course of patients	189
11.1.5	Conclusions	190
11.2	Research agenda for the future	190
11.2.1	Validity of the network theory	190
11.2.2	Understanding and predicting psychopathology	192
11.2.3	Networks in clinical practice	193
11.2.4	Methodological development	195
A	Supplementary Information to Chapter 3	201
A.1	Supplementary Methods	202
A.2	Supplementary Results	208
B	Supplementary information to chapter 6	213
B.1	The influence of γ on network estimation	214
B.2	Is severity a confound with respect to network connectivity?	216
B.3	Analyses of conceivable confounds in network connectivity	217
B.4	Quantifying importance of symptoms	217
B.5	Stability analysis of centrality measures	221
B.6	Network structures based on ordinary analyses	222
B.7	Additional indicators for weighted network density	223
C	Supplementary Information to Chapter 9	225
C.1	Derivations	226
C.1.1	Transition probabilities	226
C.2	Validation study graphicalVAR	227
C.2.1	Design	227
C.2.2	Results	227
C.3	R code for the simulation process	229
C.4	Variance	231

C.4.1	Fisher information variance	231
C.4.2	Sample variance	232
C.4.3	Comparing variance estimates	232
C.5	Violin plot of estimates of ρ not shown in Chapter 9	234
C.6	Plots of sample variances not shown in Chapter 9	235
C.7	Statistical testing	236
C.7.1	Quality of test statistic	236
D	A tutorial on R package IsingFit	239
D.1	Introduction	240
D.2	Arguments	241
D.3	Output	245
E	A tutorial on R package NetworkComparisonTest	249
E.1	Introduction	250
E.1.1	Real data to illustrate NCT	251
E.2	Arguments	252
E.3	Output	254
E.4	Plotting of NCT results	256
Bibliography		259
Nederlandse samenvatting		289
Curriculum Vitae		293
List of publications		295
PEER-REVIEWED PUBLICATIONS		295
NON PEER-REVIEWED PUBLICATIONS		298
MEDIA		298
Dankwoord (acknowledgements)		303