Early warning signals of critical transitions in mood

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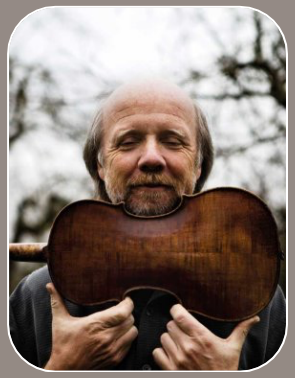
INDIANA UNIVERSITY

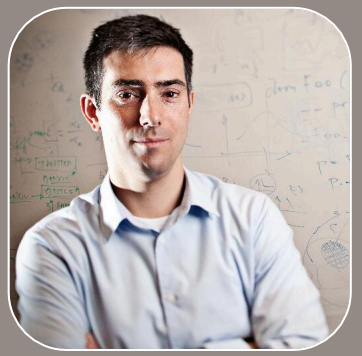
WAGENINGEN UR
For quality of life

Thanks to:

- Marieke Wichers
  Dep. of Psychiatry and Psychology, RU Groningen
- Angelique Cramer
  Dep. of Psychology, VU Amsterdam
- Denny Borsboom
  Dep. of Psychology, VU Amsterdam
- Ken Kendler
  Dep. of Psychiatry, Virginia Commonwealth University



- Johan Bollen
  Center for complex networks and systems research, Indiana University



- Marten Scheffer & Egbert van Nes
  Department of Environmental Sciences, Wageningen UR

??

Psychological Medicine (2011), **41**, 1143–1150. © Cambridge University Press 2010
doi:10.1017/S0033291710001844

ORIGINAL ARTICLE

What kinds of things are psychiatric disorders?

K. S. Kendler[1]*, P. Zachar[2] and C. Craver[3]

- Essential characteristics of mental disorders?
  Psychological, neurological, genetic..

Medical disease

Alex

Problems:

- Headaches
- Forgetfulness
- Foggy eyesight

Brain scan

Diagnosis:

- Brain tumor

Treatment:

- Surgery
- Chemotherapy

Mental disorders as medical disease

Jenny

Problems:

- Problems sleeping
- Depressed mood
- Lack of interest

DSM symptom check

Diagnosis:

- Major depression

Treatment:

- Therapy
- Antidepressants

- MD is not an empirically identifiable entity which can be treated directly (e.g. like Down syndrome or cancer)
- No lab test for MD (e.g. 3rd chromosome, tumor)

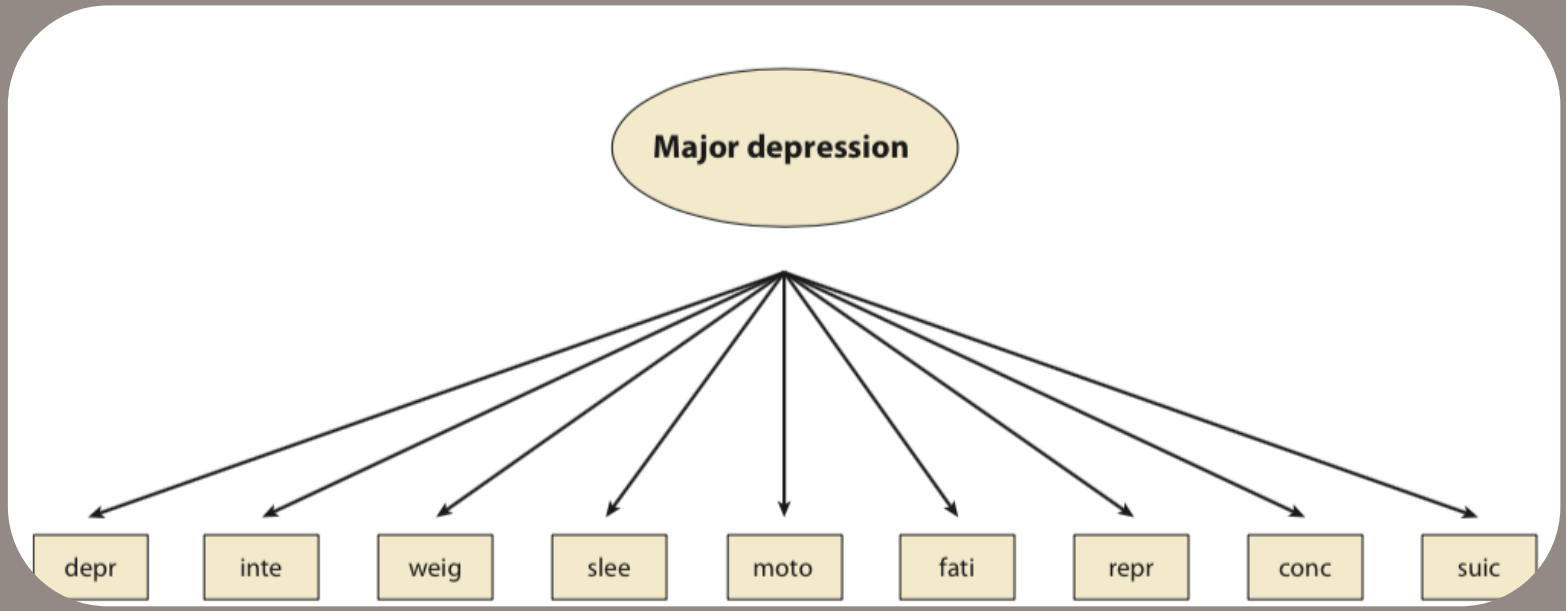
Medical disease model

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; email: D.Borsboom@uva.nl

Relation between Major Depression and its observable symptoms according to the medical disease model



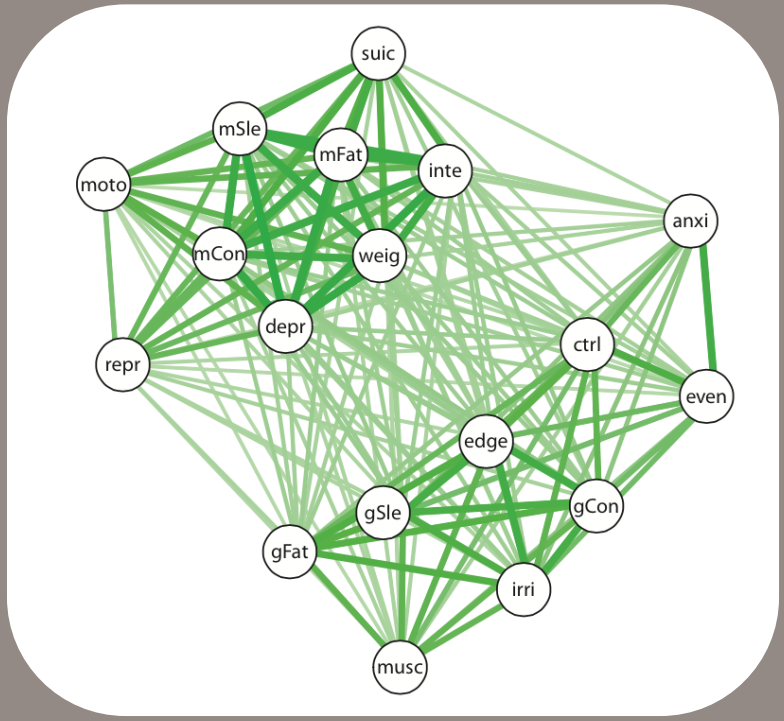
Network approach

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; email: D.Borsboom@uva.nl

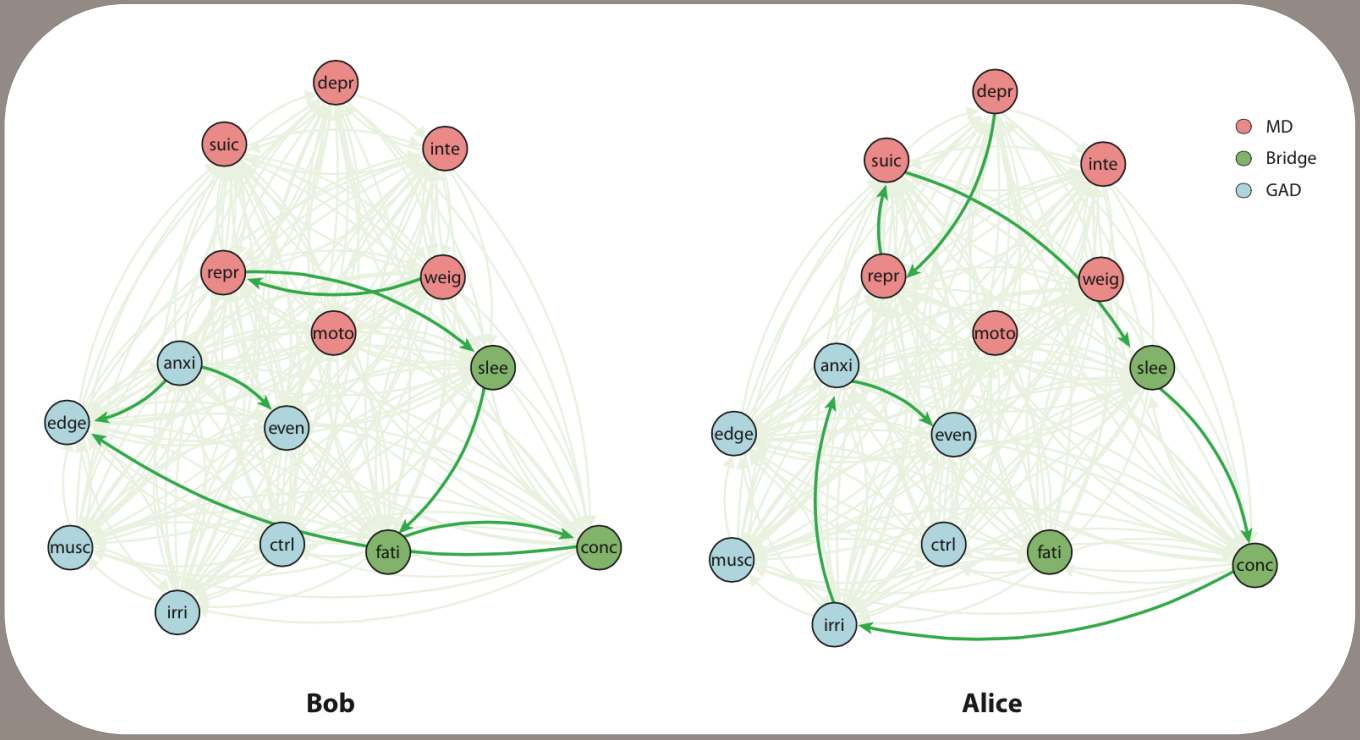
Network of Major Depression and General Anxiety Syndrome symptoms based on correlations in the National Comorbidity Survey Replication data



Symptoms could correlate because they are causally linked, instead of symptoms of a single disease

Individual differences

The network view allows us to define individual differences in terms of connection strengths (and thus individual paths to disorder):



Affected by e.g.:

- Genetic factors
- Hormones
- Life events
- Culture
- etc..

??

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doi:10.1017/S0033291710001844

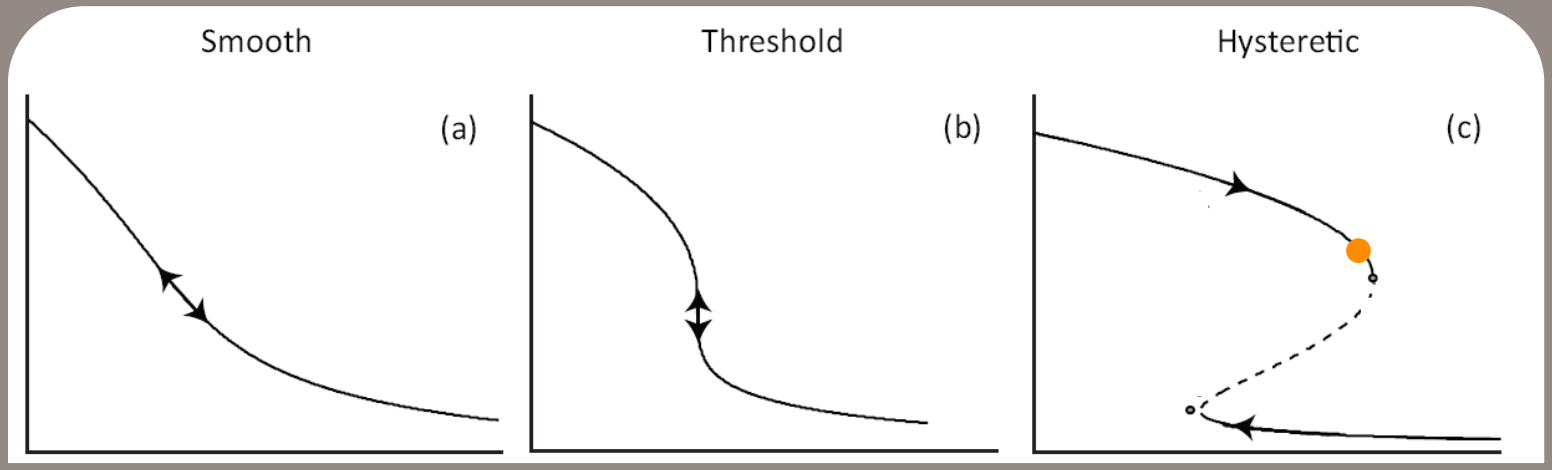
ORIGINAL ARTICLE

What kinds of things are psychiatric disorders?

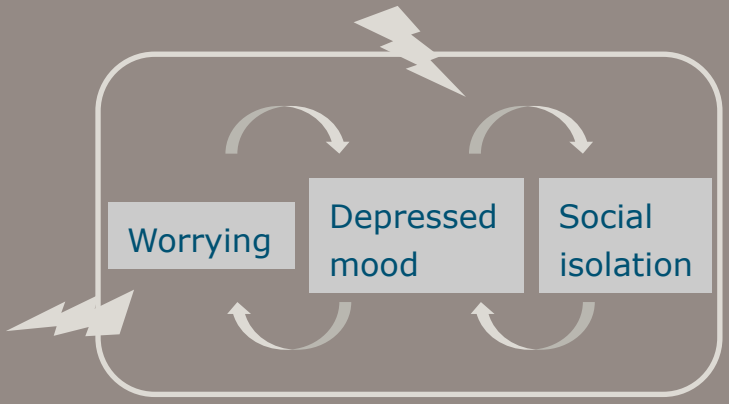
K. S. Kendler[1]*, P. Zachar[2] and C. Craver[3]

- Kendler et al. essentially propose to view mental disorders as attractors in a large complex dynamical system

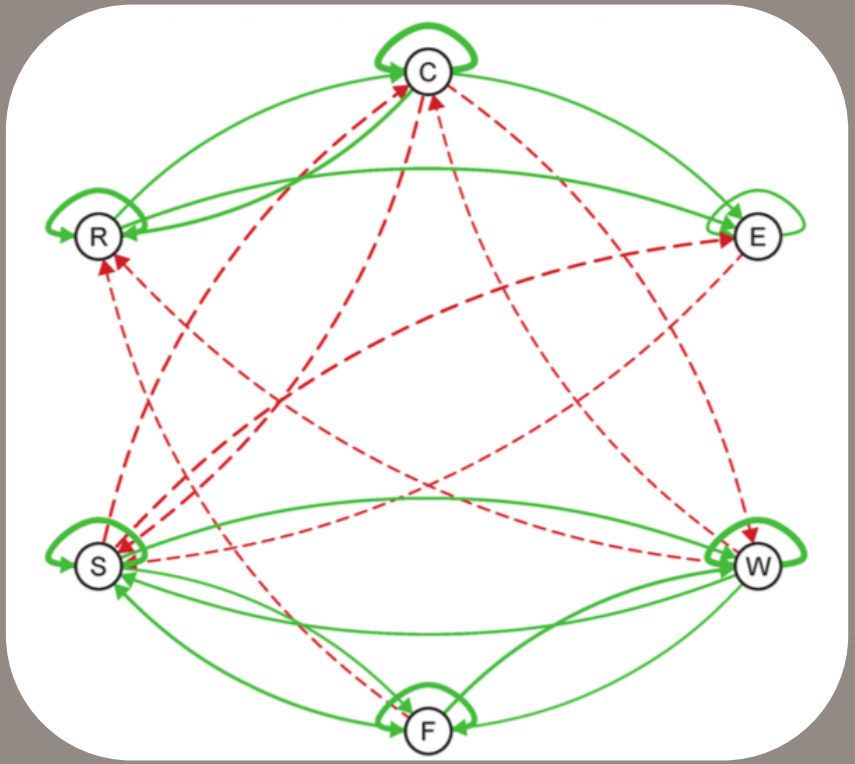
Depression as a tipping point?



Small perturbation
(e.g. upsetting phone call)



Indications of positive feedbacks



Mood-related factors:

R = relaxed
C = cheerful
E = pleasant event

S = sad
F = fearful
W = worry

OPEN ACCESS Freely available online

PLOS ONE

A Network Approach to Psychopathology: New Insights into Clinical Longitudinal Data

Laura F. Bringmann[1]*, Nathalie Vissers[1], Marieke Wichers[2], Nicole Geschwind[3], Peter Kuppens[1], Frenk Peeters[2], Denny Borsboom[4], Francis Tuerlinckx[1]

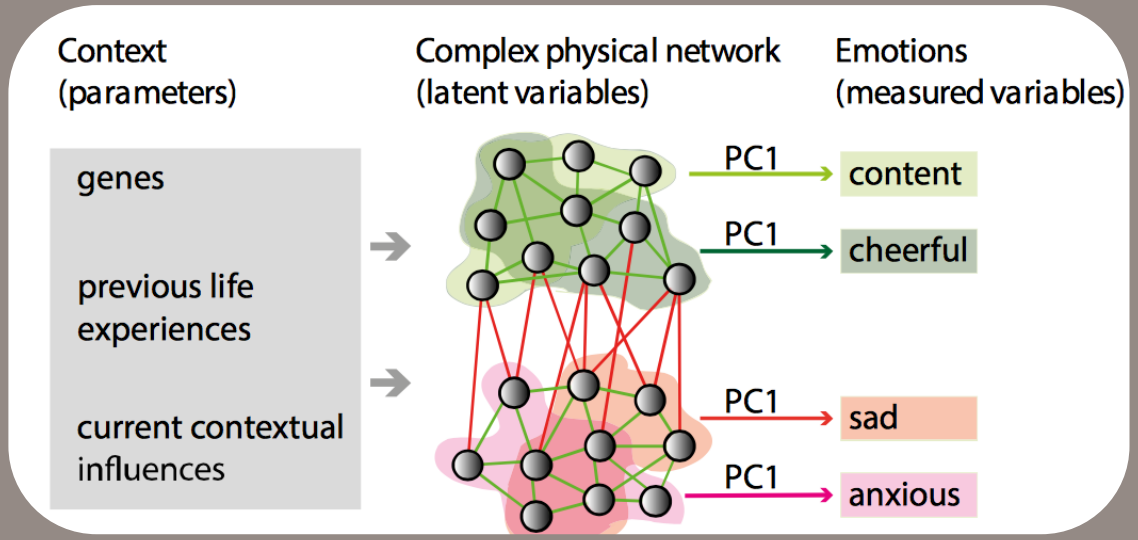
Early warning signals illustrated with a model describing mood dynamics

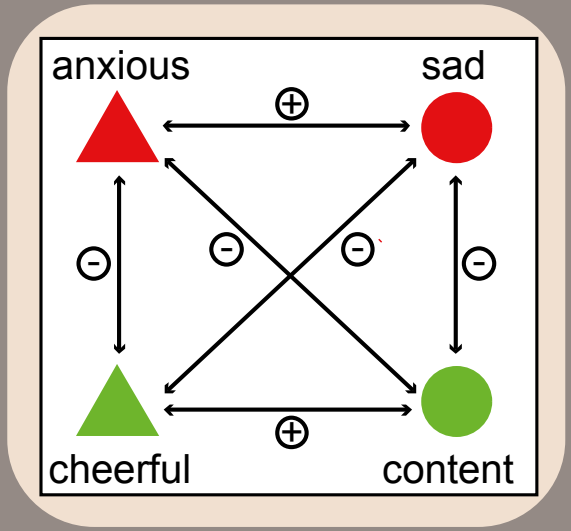
PNAS

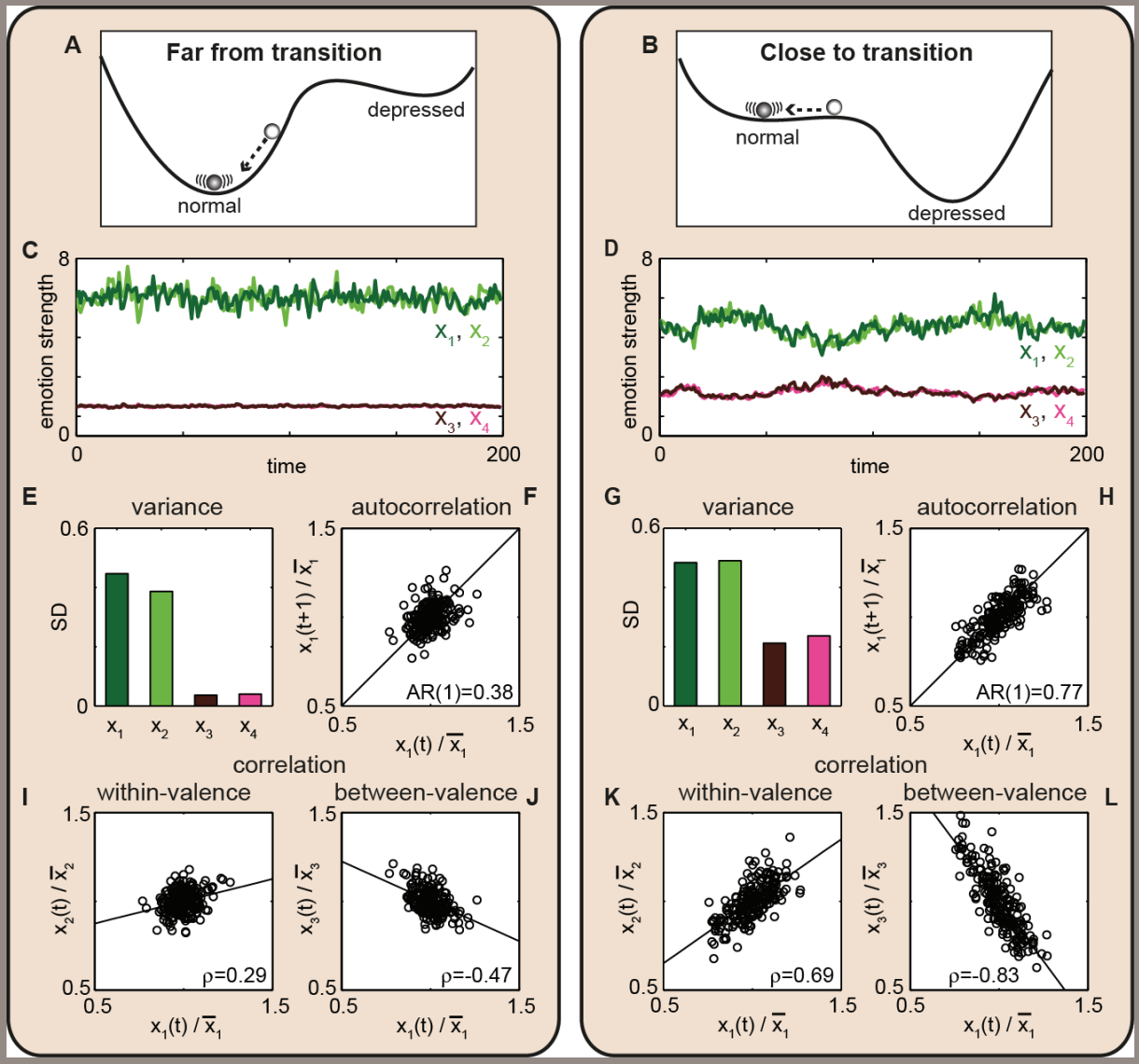
Critical slowing down as early warning for the onset and termination of depression

Ingrid A. van de Leemput[a,1,2], Marieke Wichers[b,1], Angélique O. J. Cramer[c], Denny Borsboom[c], Francis Tuerlinckx[d], Peter Kuppens[d,e], Egbert H. van Nes[a], Wolfgang Viechtbauer[b], Erik J. Giltay[f], Steven H. Aggen[g], Catherine Derom[h,i], Nele Jacobs[b,j], Kenneth S. Kendler[g,k], Han L. J. van der Maas[c], Michael C. Neale[g], Frenk Peeters[b], Evert Thiery[l], Peter Zachar[m], and Marten Scheffer[a]

[a]Aquatic Ecology and Water Quality Management, Wageningen University, 6700 AA, Wageningen, The Netherlands; [b]Department of Psychiatry and Psychology, School for Mental Health and Neuroscience, Maastricht University, 6200 MD, Maastricht, The Netherlands; [c]Department of Psychology, Psychological Methods, University of Amsterdam, 1018 XA, Amsterdam, The Netherlands; [d]Faculty of Psychology and Educational Sciences, KU Leuven–University of Leuven, 3000 Leuven, Belgium; [e]Melbourne School of Psychological Sciences, University of Melbourne, Melbourne, VIC 3010, Australia; [f]Department of Psychiatry, Leiden University Medical Center, 2300 RC, Leiden, The Netherlands; [g]Virginia Institute for Psychiatric and Behavioral Genetics






A
Far from transition
depressed
normal
B
Close to transition
normal
depressed
C
emotion strength
8
0
x_1, x_2
x_3, x_4
0
200
time
D
emotion strength
8
0
x_1, x_2
x_3, x_4
0
200
time
E
variance
SD
0.6
0
x_1 x_2 x_3 x_4
F
autocorrelation
$x_1(t+1) / \bar{x}_1$
1.5
0.5
AR(1)=0.38
0.5
1.5
$x_1(t) / \bar{x}_1$
G
variance
SD
0.6
0
x_1 x_2 x_3 x_4
H
autocorrelation
$x_1(t+1) / \bar{x}_1$
1.5
0.5
AR(1)=0.77
0.5
1.5
$x_1(t) / \bar{x}_1$
correlation
I
within-valence
$x_2(t) / \bar{x}_2$
1.5
0.5
ρ=0.29
0.5
1.5
$x_1(t) / \bar{x}_1$
J
between-valence
$x_3(t) / \bar{x}_3$
1.5
0.5
ρ=-0.47
0.5
1.5
$x_1(t) / \bar{x}_1$
correlation
K
within-valence
$x_2(t) / \bar{x}_2$
1.5
0.5
ρ=0.69
0.5
1.5
$x_1(t) / \bar{x}_1$
L
between-valence
$x_3(t) / \bar{x}_3$
1.5
0.5
ρ=-0.83
0.5
1.5
$x_1(t) / \bar{x}_1$

Temporal data!! ESM: Experience Sampling Method

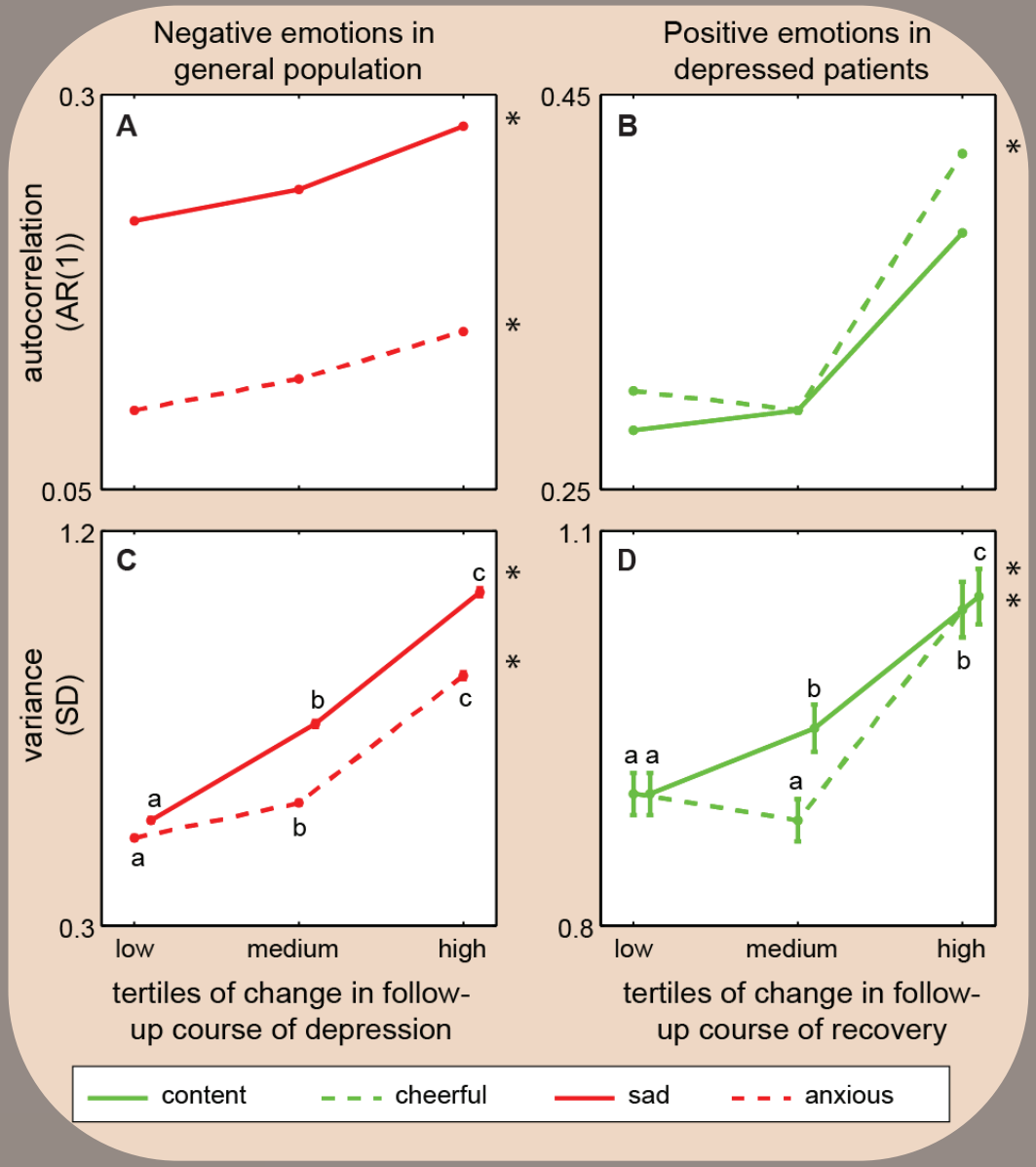
- 2 populations:
  - General (without diagnosis depression) (n=535)
  - Depressed (with diagnosis depression) (n=93)

Emotion	Current state (1-7)
Content	…
Satisfied	…
Anxious	…
Sad	…

- 6 consecutive days, 10 times a day (7:30 - 22:30)
- Monitoring of follow-up course depressive symtoms

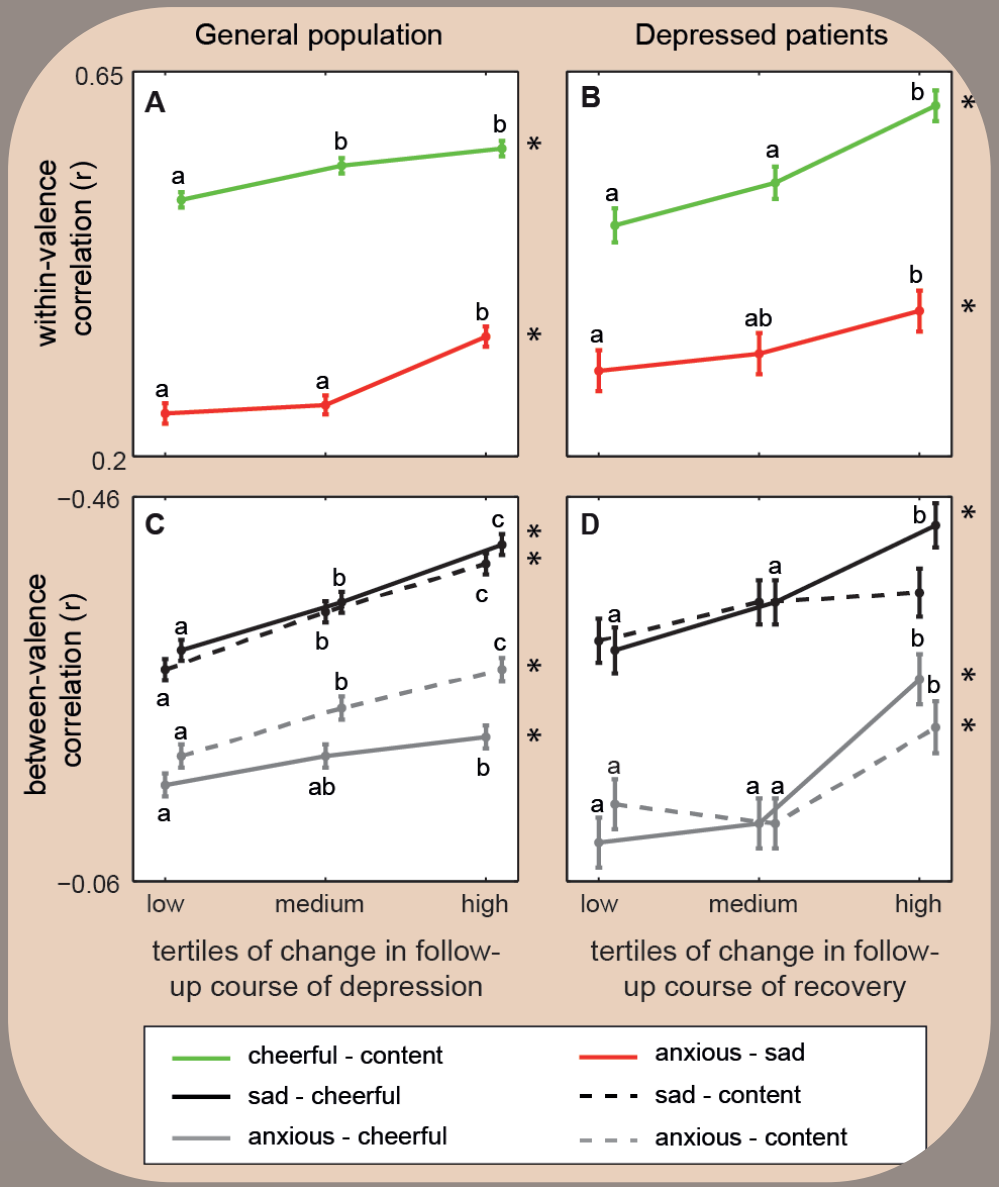
Results

- General population closer to depression:
  - Higher autocorrelation and variance of negative emotions
- Depressed population closer to recovery:
  - Higher autocorrelation and variance of positive emotions

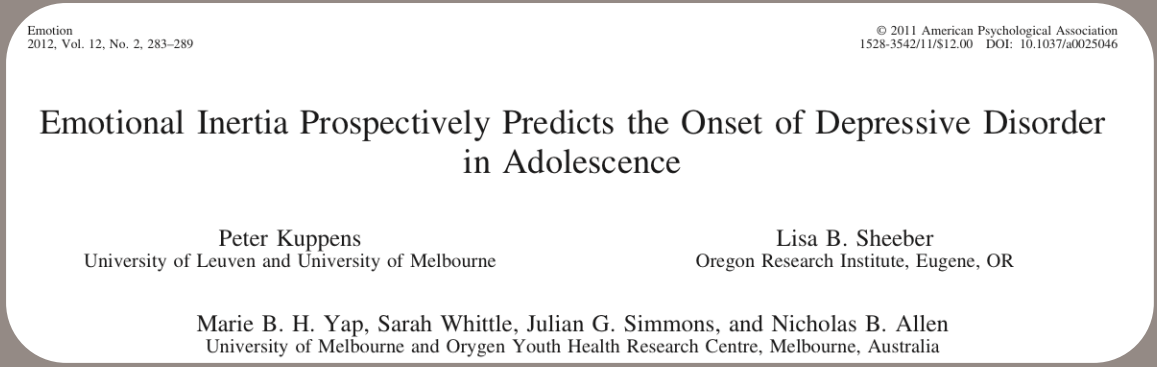

Negative emotions in general population
Positive emotions in depressed patients
autocorrelation (AR(1))
variance (SD)
A
B
C
D
0.3
0.05
0.45
0.25
1.2
0.3
1.1
0.8
*
*
*
*
*
*
a
b
c
a
b
c
a a
a
b
c
low
medium
high
tertiles of change in follow-up course of depression
tertiles of change in follow-up course of recovery
content
cheerful
sad
anxious

Results

- General population closer to depression:
  - Higher autocorrelation and variance of negative emotions
  - Higher correlation between emotions
- Depressed population closer to recovery:
  - Higher autocorrelation and variance of positive emotions
  - Higher correlation between emotions


General population
Depressed patients
0.65
0.2
within-valence correlation (r)
A
B
C
D
−0.46
−0.06
between-valence correlation (r)
low
medium
high
tertiles of change in follow-up course of depression
tertiles of change in follow-up course of recovery
cheerful - content
sad - cheerful
anxious - cheerful
anxious - sad
sad - content
anxious - content

Emotional Inertia



Emotion
2012, Vol. 12, No. 2, 283–289

1528-3542/11/$12.00 DOI: 10.1037/a0025046

Emotional Inertia Prospectively Predicts the Onset of Depressive Disorder in Adolescence

Peter Kuppens
University of Leuven and University of Melbourne

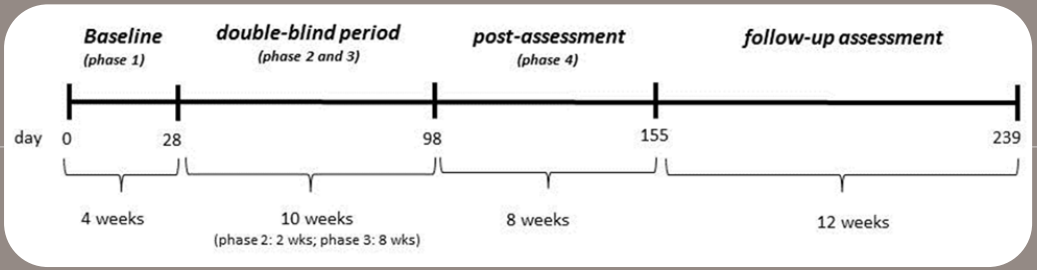
Lisa B. Sheeber
Oregon Research Institute, Eugene, OR

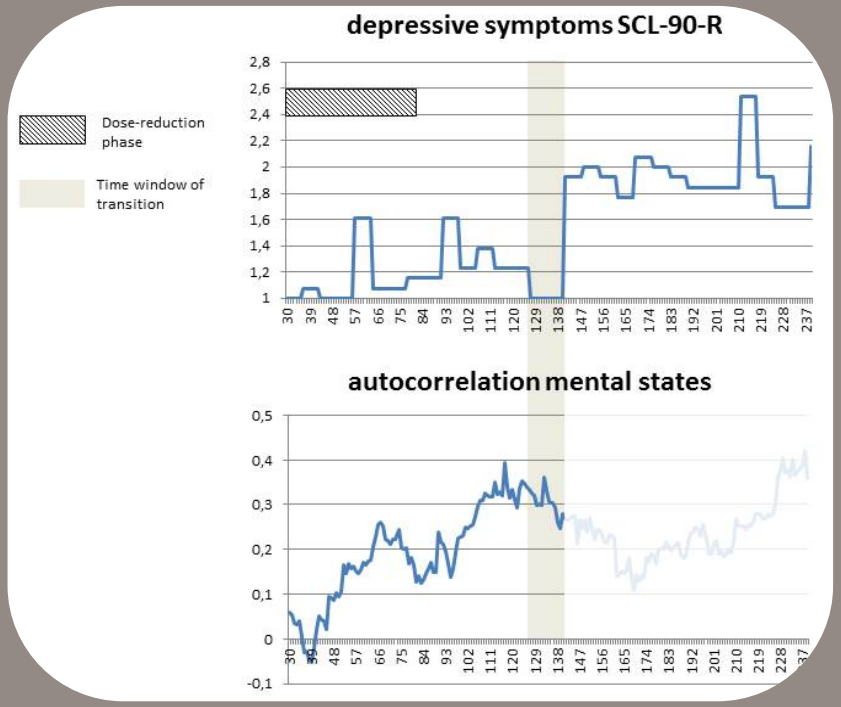
Marie B. H. Yap, Sarah Whittle, Julian G. Simmons, and Nicholas B. Allen
University of Melbourne and Orygen Youth Health Research Centre, Melbourne, Australia

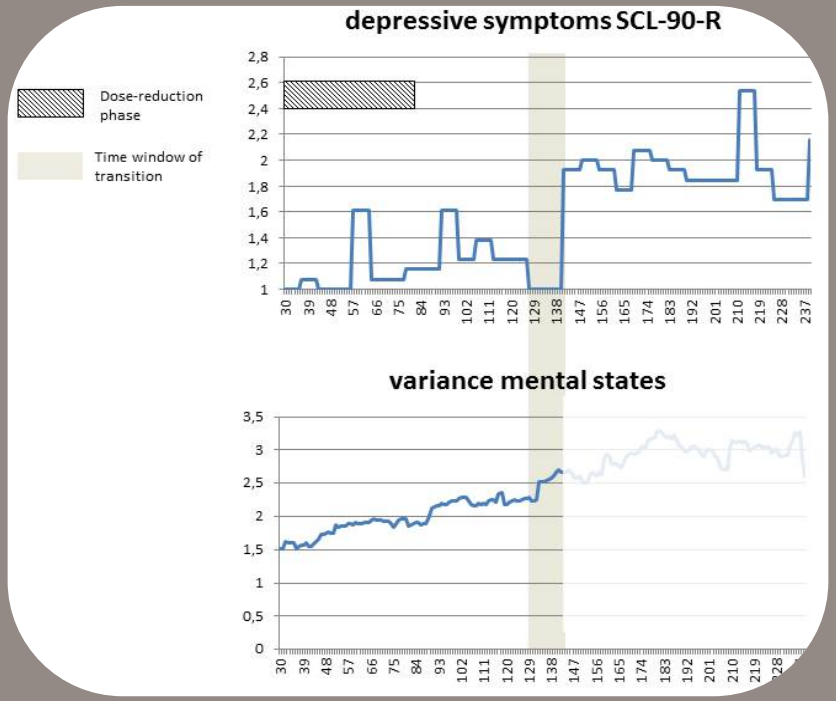
- Emotional inertia "*refers to the degree to which a person's current emotional state is predicted by their prior emotional state, reflecting how much it carries over from one moment to the next*"
- Increased emotional inertia predictive of onset of depressive disorder

Individual-level

Wichers et al. *under review*



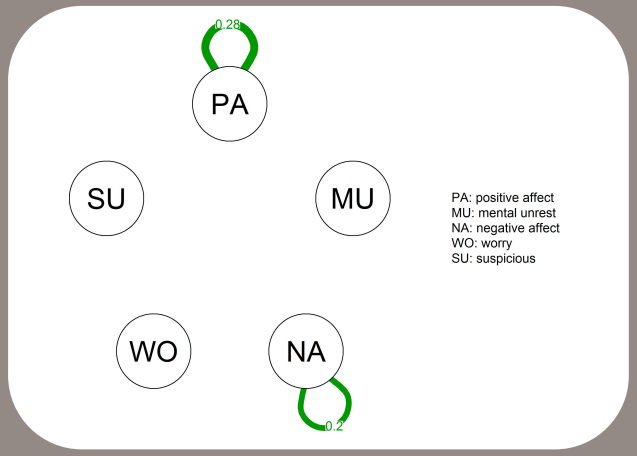




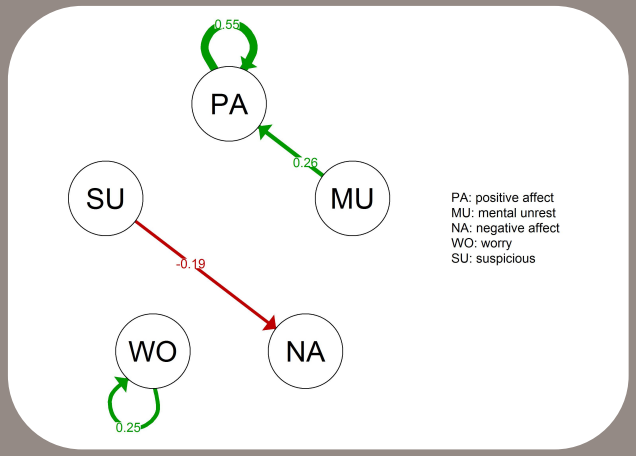
Individual-level

Wichers et al. *under review*

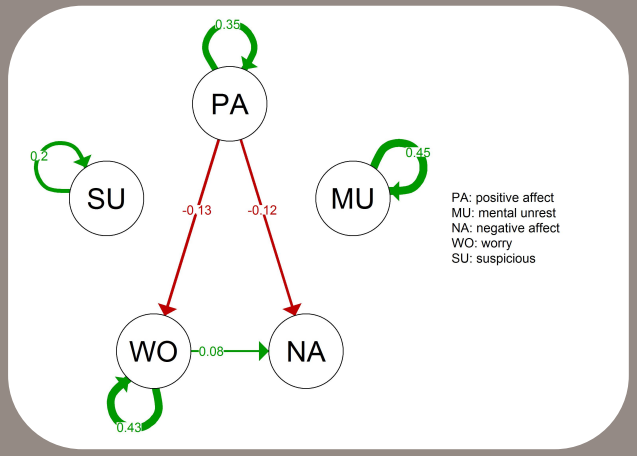
Phase 1 (before experiment)



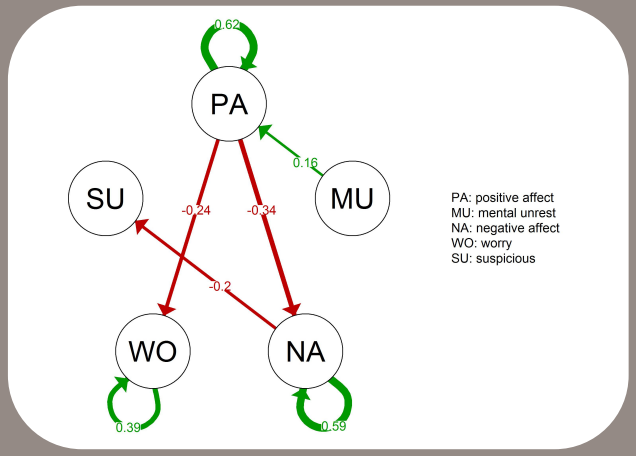
Phase 2 (no anti-depr reduction)



Phase 3 (anti-depr reduction)



Phase 4 (before shift)



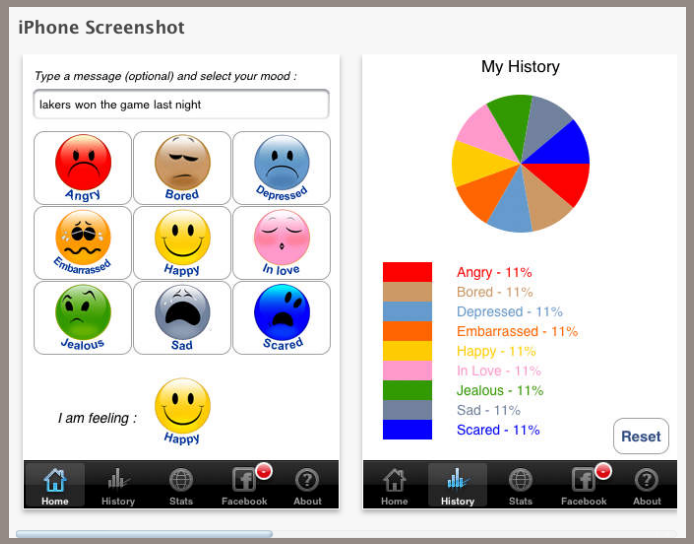
Conclusions depression experiments

- Increased autocorrelation, variance, and correlation between emotions indicative for proximity 'transition' towards depression, and towards healthy state
- 1) Indication of positive feedbacks,
  2) abrupt shifts, and
  3) early warning signals
  suggest that depression and healthy state are alternative stable states..
- .. and transitions between them are critical transitions/ tipping points
- Our results strengthen the network view of mental disorders
- Circumvent full understanding, but still improve ability to anticipate clinically relevant mood shifts

Future issues ..

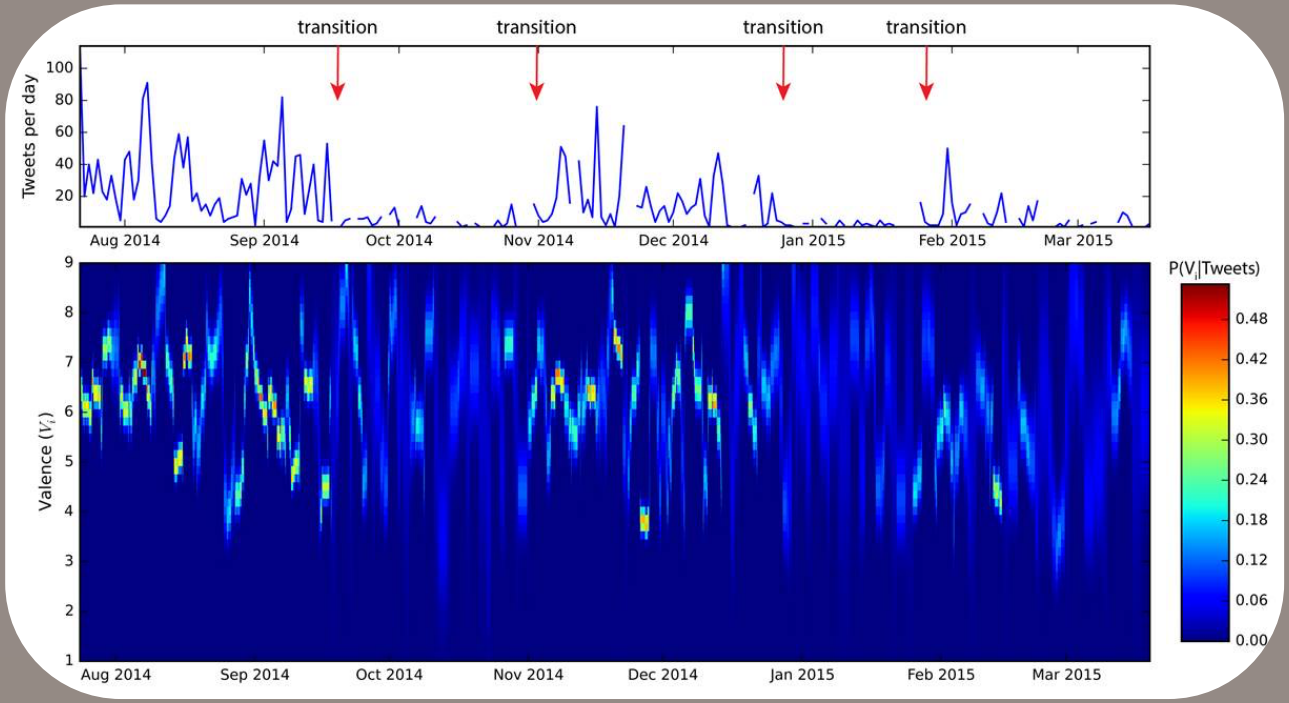
- What do the many roads to developing mental disorders look like?
- What sort of genetic/biological, psychological, and environmental factors govern individual differences in the strength of connections between symptoms?
- Replication of individual-level experiment (currently n=1)
- Causal links between symptoms? Convergent cross-mapping..
- How can the theory of early warning signals help in targeting and evaluating therapeutic interventions?

Mood tracking apps, rely on self-assessment

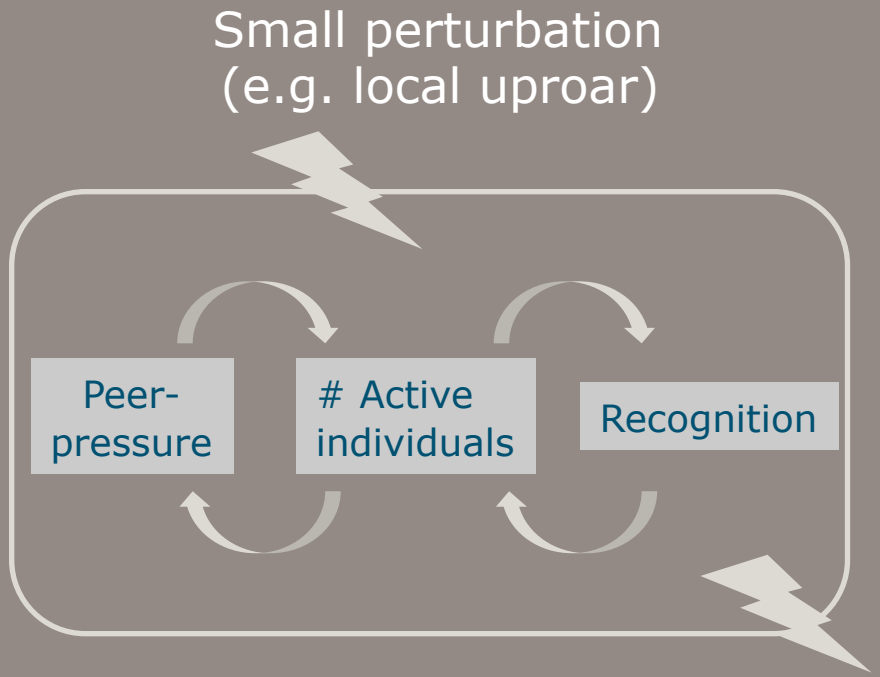


Tracking mood in social media updates

- Twitter: “I was diagnosed bipolar” or “I was diagnosed depression”
- Sentiment analysis from short texts



Social tipping points.. early warning signals



Thank you

ingrid.vandeleemput@wur.nl

Network approach

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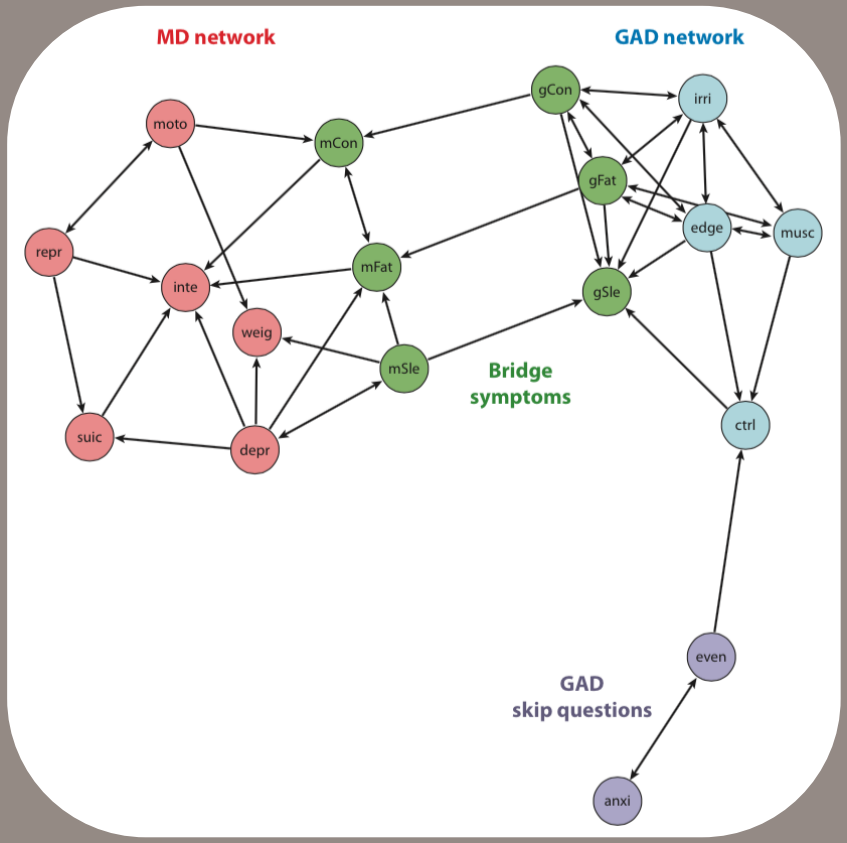
Network of Major Depression and General Anxiety Syndrome symptoms
based on putative causal relations between symptoms



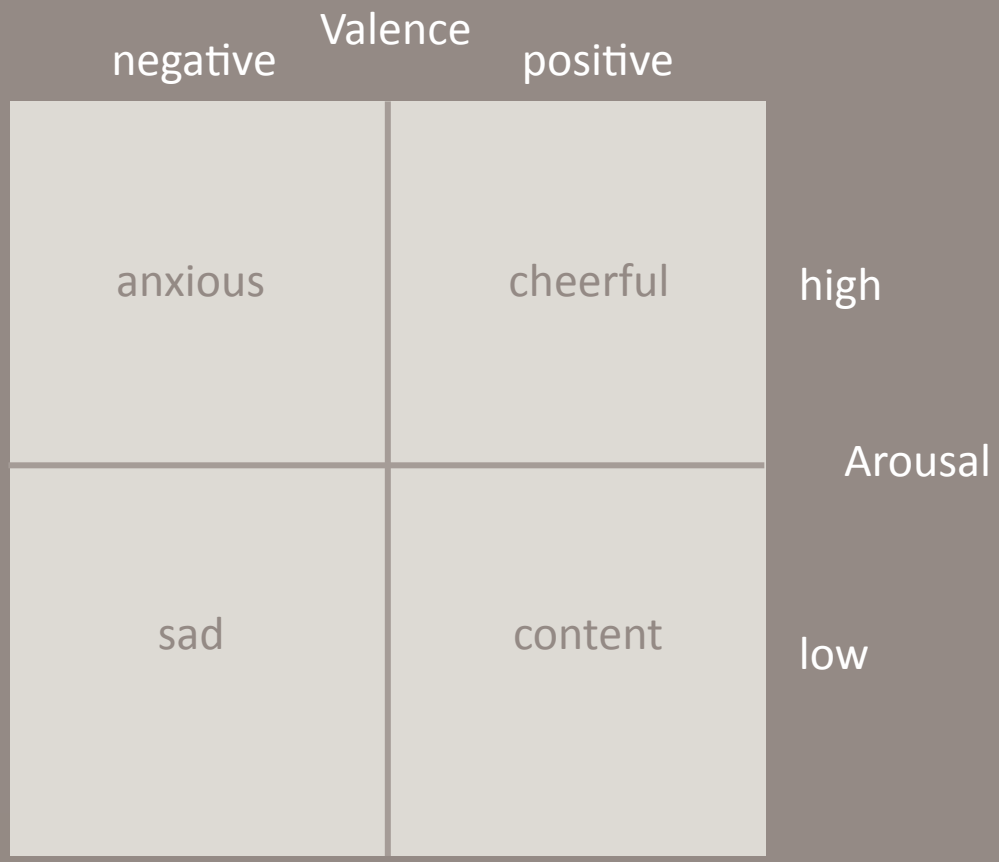
The model

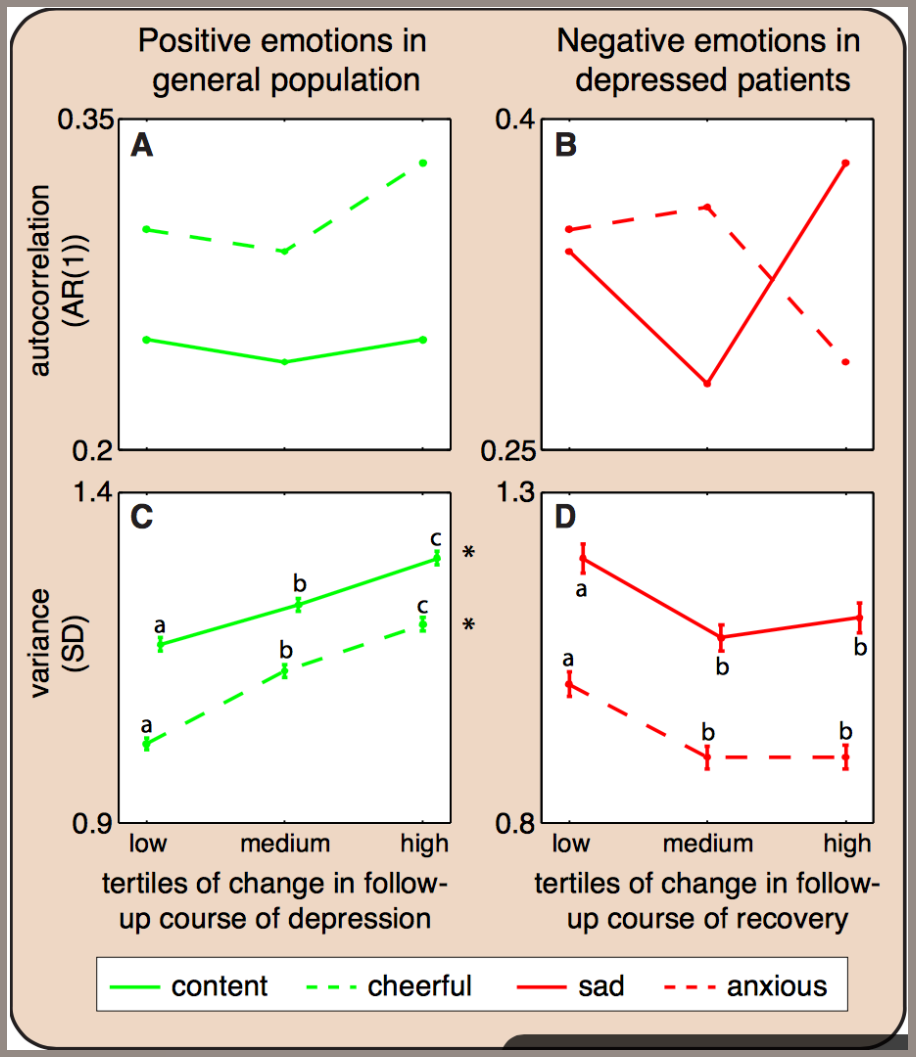
$$\frac{dx_i}{dt} = (r_i + \epsilon_r)x_i + \sum_j^4 C_{i,j}x_j x_i + \mu,$$

$$C = \begin{pmatrix} -0.2 & 0.04 & -0.2 & -0.2 \\ 0.04 & -0.2 & -0.2 & -0.2 \\ -0.2 & -0.2 & -0.2 & 0.04 \\ -0.2 & -0.2 & 0.04 & -0.2 \end{pmatrix}$$

ESM: Experience Sampling Method

- The four emotions were a-priori chosen to represent each quadrant of the affective space:




Positive emotions in general population
Negative emotions in depressed patients
A
B
C
D
0.35
0.2
0.4
0.25
1.4
0.9
1.3
0.8
autocorrelation (AR(1))
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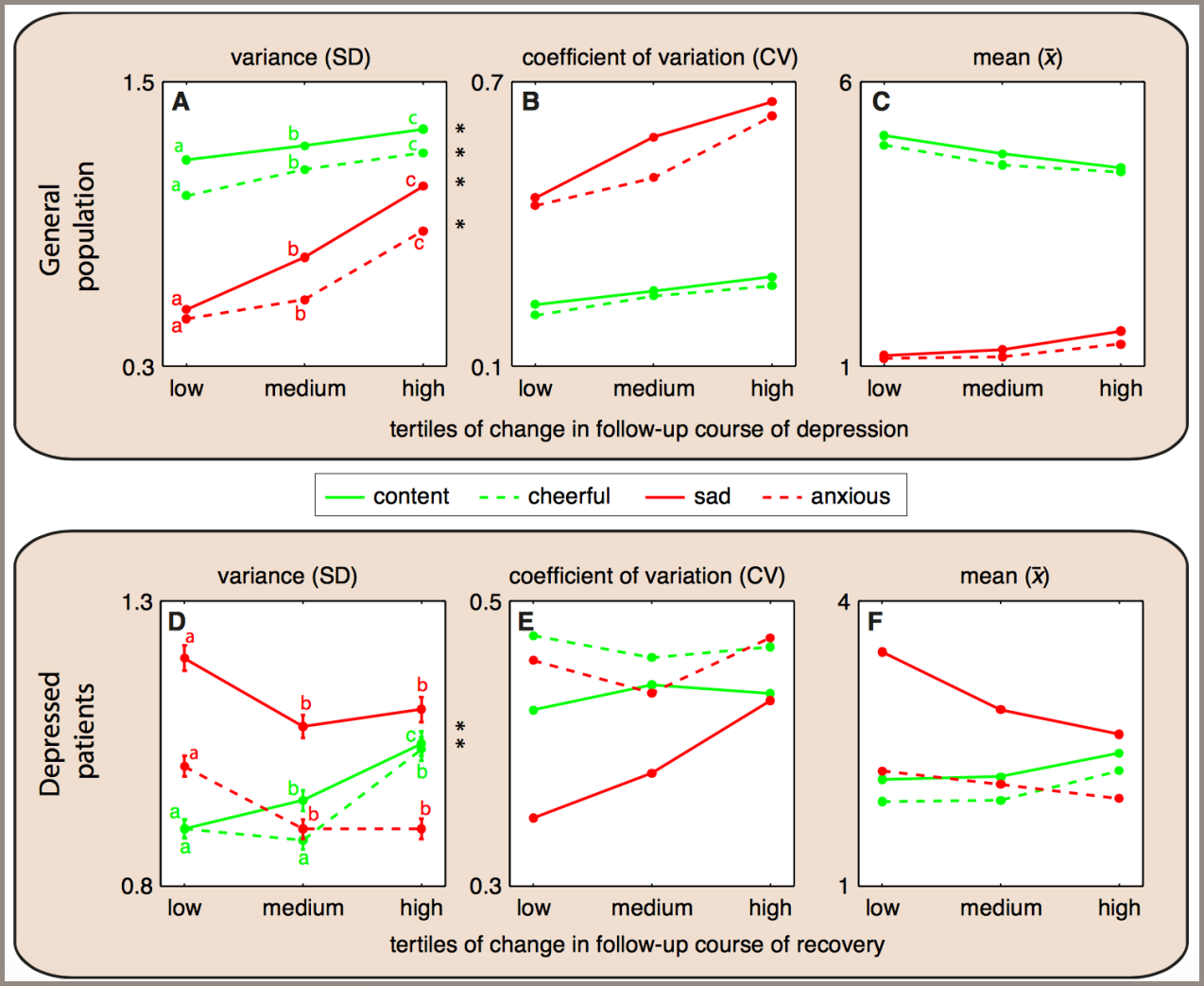
General population
variance (SD)
coefficient of variation (CV)
mean ($\bar{x}$)
A
B
C
1.5
0.3
0.7
0.1
6
1
low
medium
high
tertiles of change in follow-up course of depression
content
cheerful
sad
anxious
Depressed patients
D
E
F
1.3
0.8
0.5
0.3
4
1
tertiles of change in follow-up course of recovery