Dynamic network analysis of depression symptoms

Talya Greene

Department of Community Mental Health

University of Haifa

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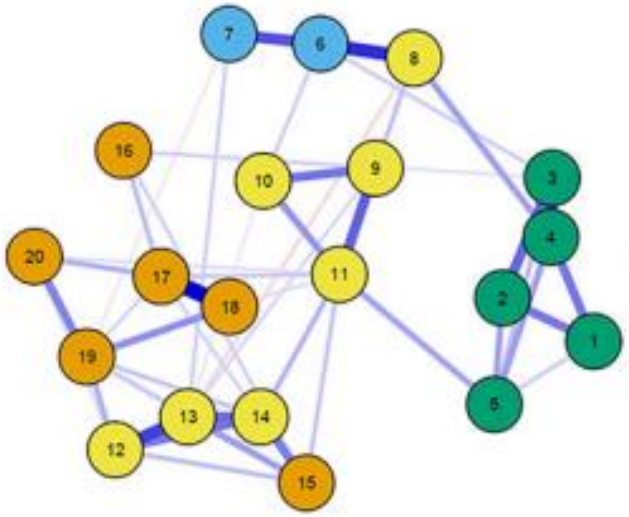
Psychopathological network

- Network = entities that are connected to each other in some way.
- Network theory of psychopathology (e.g., Borsboom, 2017) - rather than resulting from some kind of underlying latent factor that drives symptoms, the symptoms and their interactions actually constitute the disorder.
- Makes intuitive sense - clinically we are interested in the ways that different symptoms, states, and behaviors drive each other.



Psychopathological network analysis

- Last few years – exponential growth in network analysis studies.
- Typically psychiatric symptoms, emotions, behaviors.
- Often connections within a diagnostic construct
- Comorbidity - Connections between a construct and some other phenomena/constructs
- Depression, anxiety, PTSD, eating disorders, OCD, schizophrenia, and many more
- Mostly cross-sectional data.

Experience sampling method

- Experience sampling/ecological momentary assessment/daily diary studies
- Intensive longitudinal data in real-time, real world environments
- Usually at least once a day.
- Smartphones, wearables made this increasingly accessible
- Increased ecological validity
- Better able to capture complexity
- Enables the examination of processes as they unfold within individuals over time

Where networks meets ESM

- Time series networks (N=1 or N>1)
- Network analysis extended: dynamic networks
- Based on (multilevel) vector autoregression models
- Variables are regressed on all other variables in the network as well as themselves at previous time point
- Directed networks that show direction, sign and strength of association
- These networks better capture network theory – changes in one symptom impact on changes in other symptoms – *potential causal mechanisms*

Time-series/Dynamic networks

- **Temporal** network - lagged (measurement to measurement) associations between variables
- **Contemporaneous** network – concurrent (within-measurement) associations between variables (controlling for temporal)
- **Between-persons** network – uses the average per-person association between each pair of nodes for estimation.

Temporal networks **enable estimation of:**

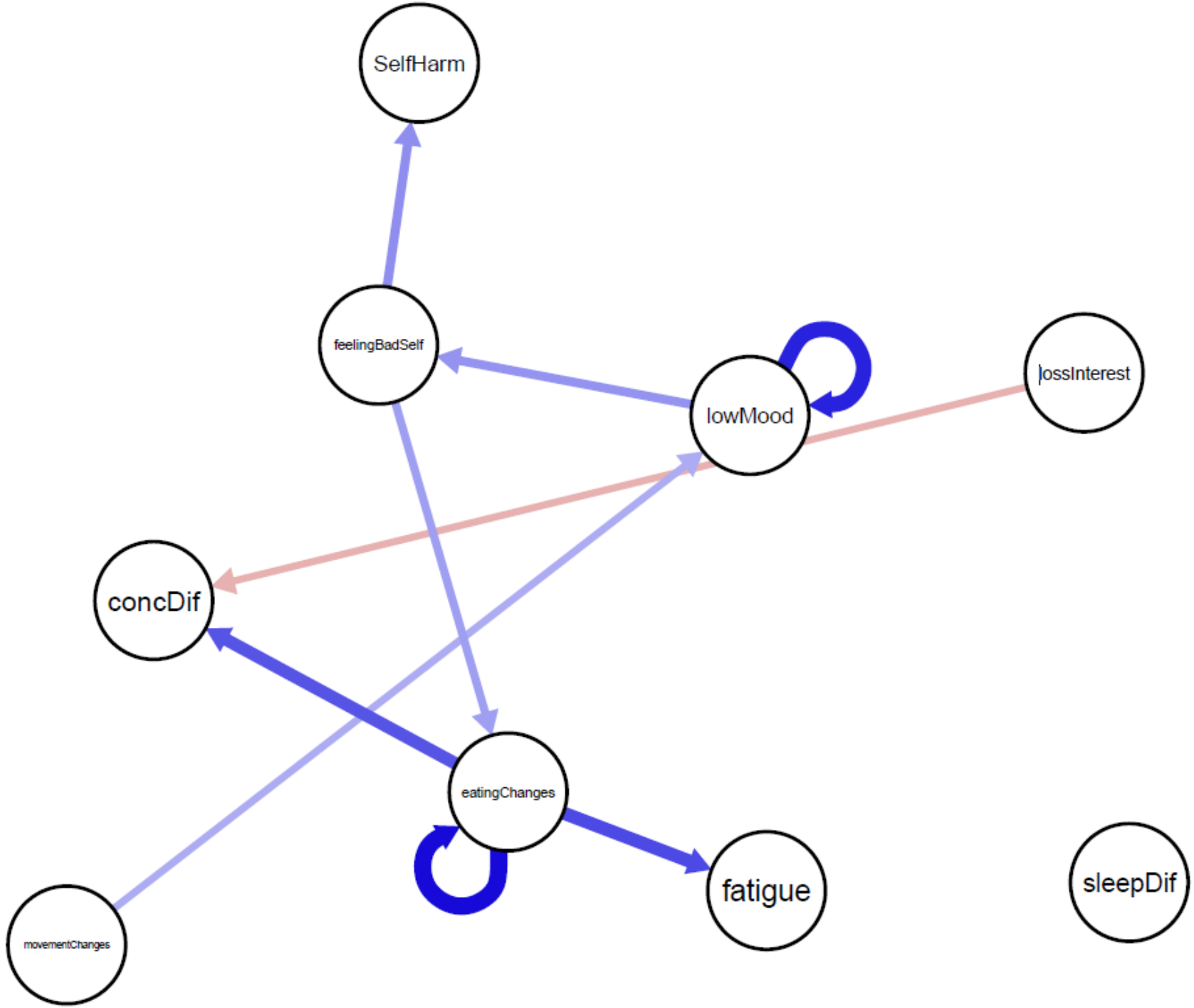
- **In-strength** – the extent to which a variable is predicted by other variables at the previous measurement
- **Out-strength** – the extent to which a variable predicts other variables at the next measurement
- **Autoregression**– symptoms which predict themselves at the next measurement

Dynamic network of depression symptoms

- Raise some of the (many) questions I have about it (potential limitations)
- Study - part of a multi-wave ESM project investigating reactions during and after conflict exposure
- Data are from the third ESM round – 42 months after the conflict exposure.

Method

- 89 participants – community sample
- ESM reports 2x a day for 17 days.
- Total of 2653 observations (ave of 29.8 out of potential 34).
- Depression symptoms – Adapted version of the PHQ-9 - (‘since the last questionnaire, 4-point Likert).
- Used a two-step multilevel VAR network analysis in R (mlvar, qgraph, networktools).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feelingBadSelf
lowMood
lossInterest
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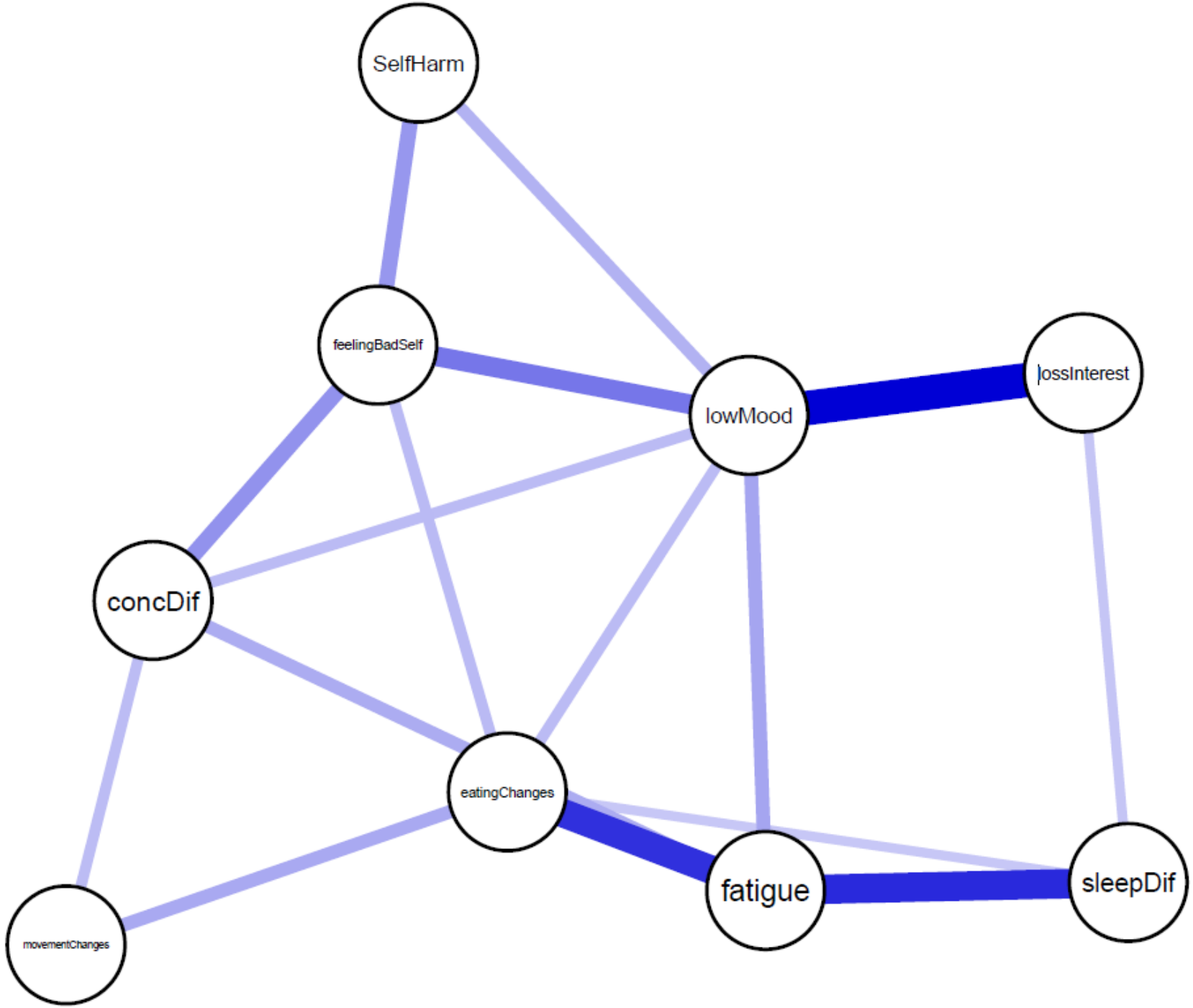
eatingChanges
fatigue
sleepDif
movementChanges


SelfHarm
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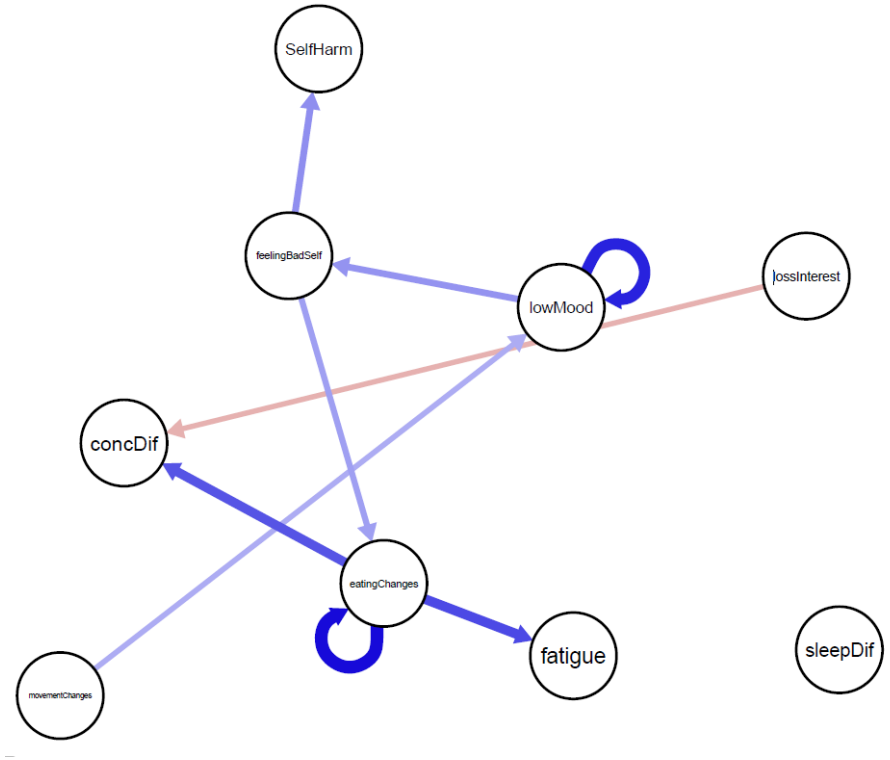
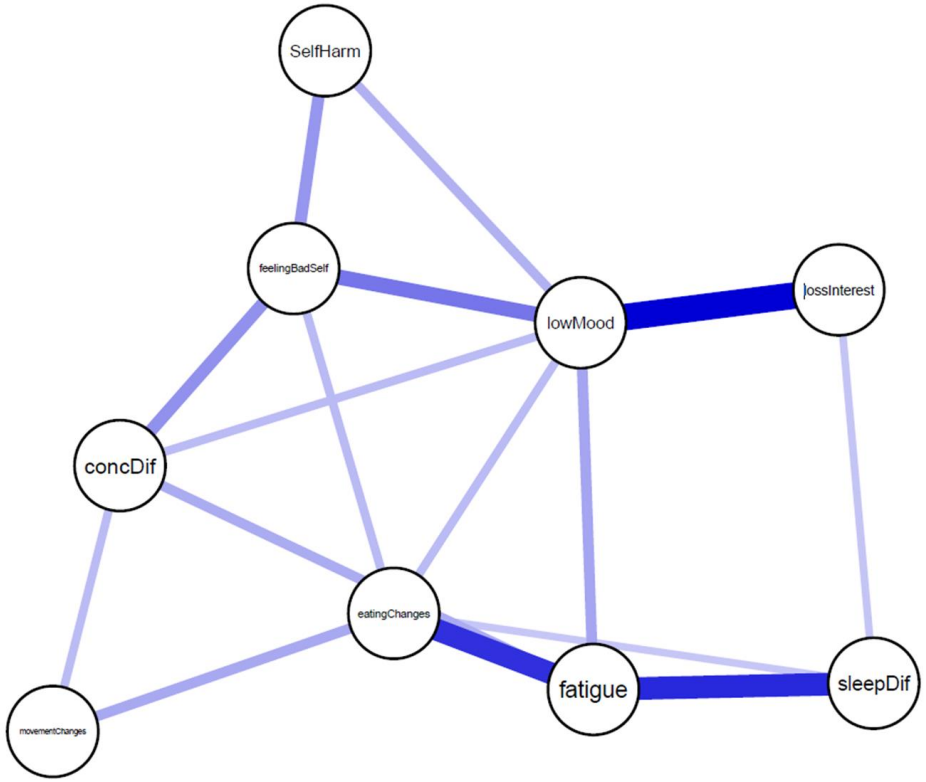
Measurement to measurement (temporal)

- Eating changes highest out-strength.
  - Connections with concentration difficulties and fatigue
- In turn, concentration difficulties and fatigue highest in-strength.
- Sleep difficulties not connected.
- Changes in eating and low mood predicted themselves (were autoregressive).



Within measurement - Contemporaneous

- PHQ-9 Depression symptoms = positive associations (including sleep difficulties)
- Most central - feeling down, depressed or hopeless
- Least central - Moving or speaking slower or faster than usual

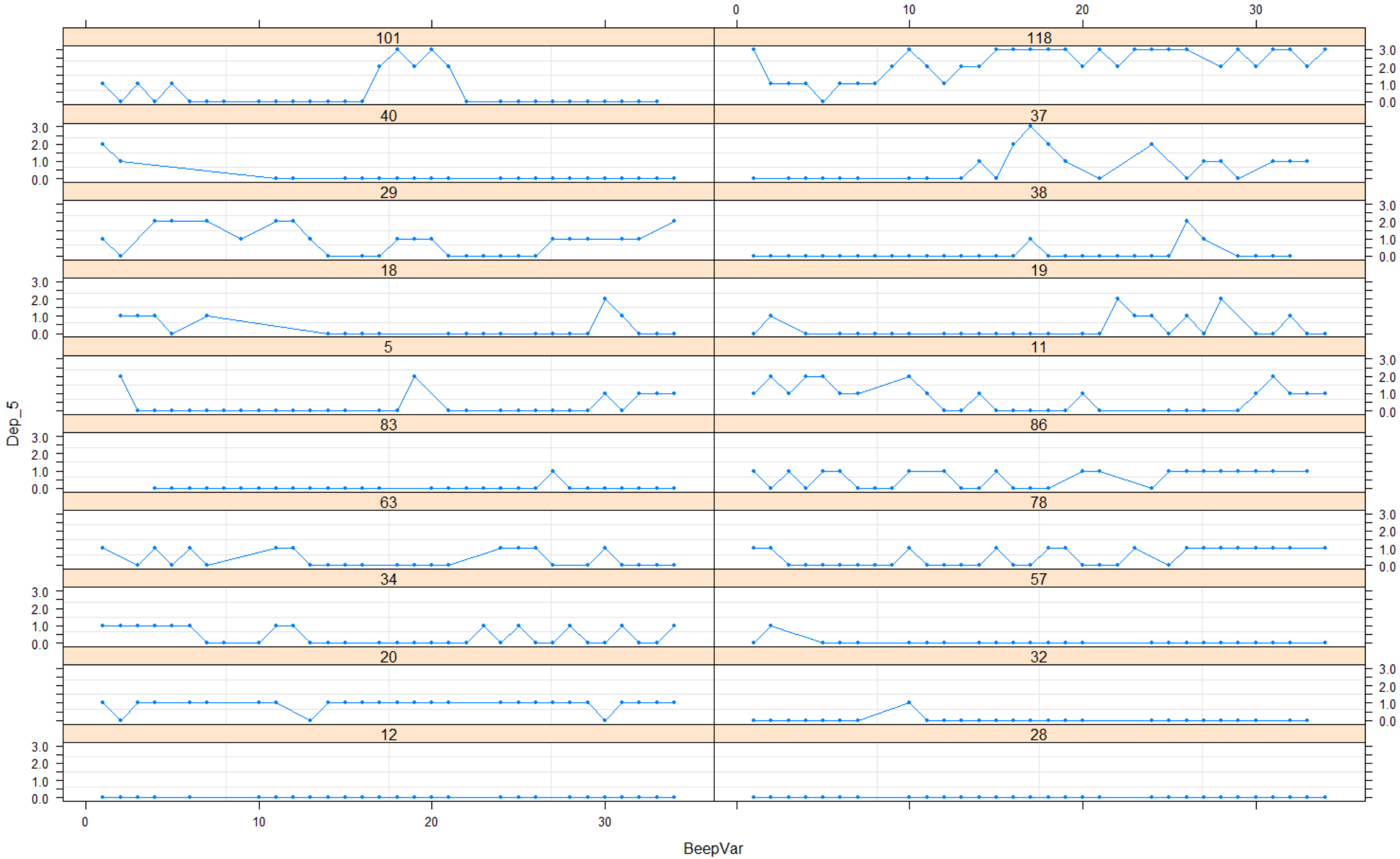


Tempting and easy interpretation….

- BUT!
- Many questions
- Will raise just a few – food for thought

Stationarity and detrending

- Model assumption - stationarity
- Few papers, most often detrending.
- Per person, per variable
- Case to be made if you expect to see an overall pattern of change. E.g., during treatment.
- BUT – look at panel plots (random sample of 20)


101
118
40
37
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34
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20
32
12
28
Dep_5
BeepVar
0
10
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0.0
1.0
2.0
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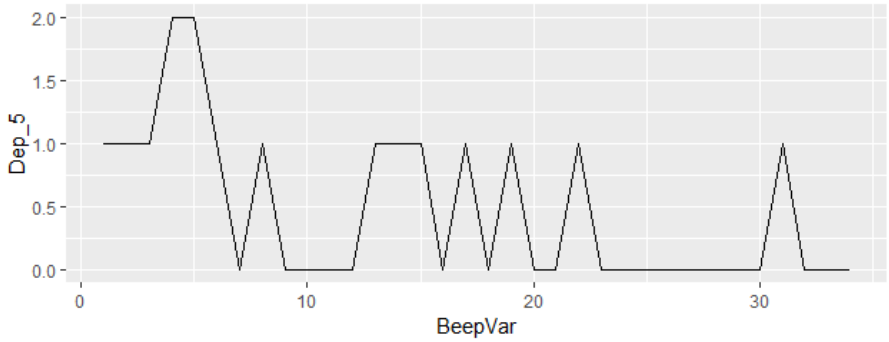
A word of caution - detrending

- Participant 119 for example
- Significant linear trend
- What would happen if I ‘fix’ this by detrending?
  - Using a linear approach to ‘correct’ nonlinear observations may introduce more problems than they fix

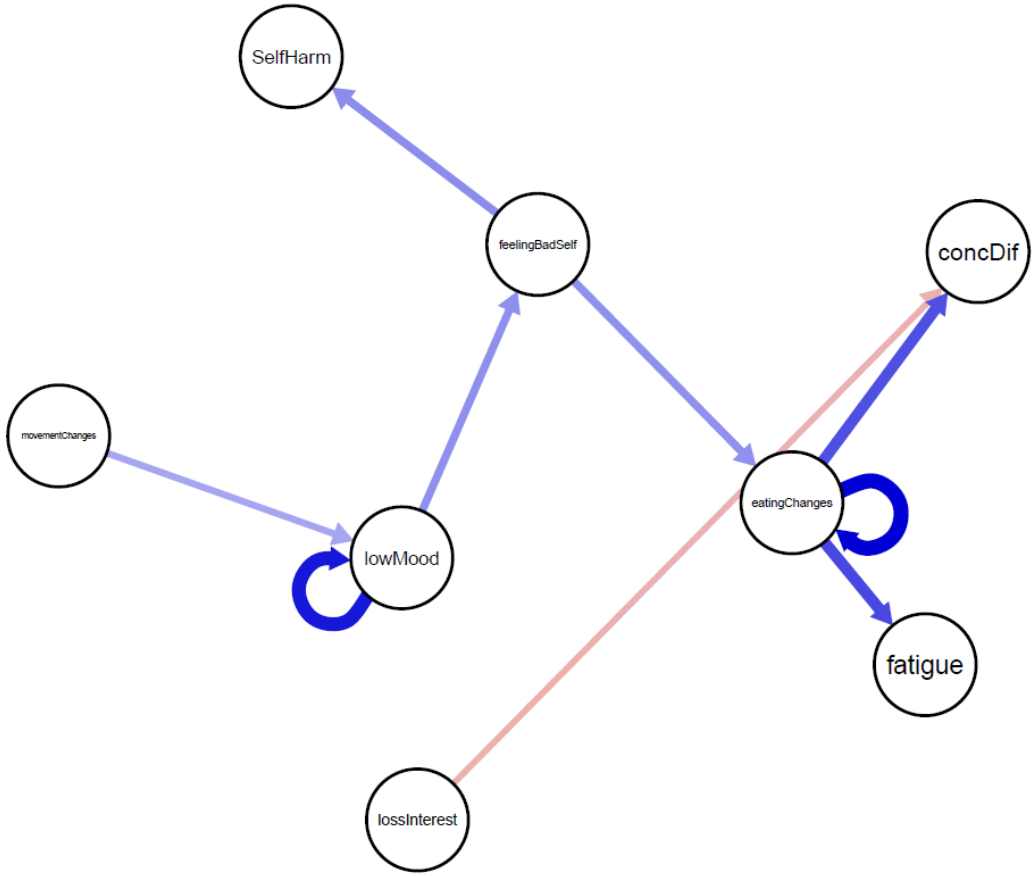


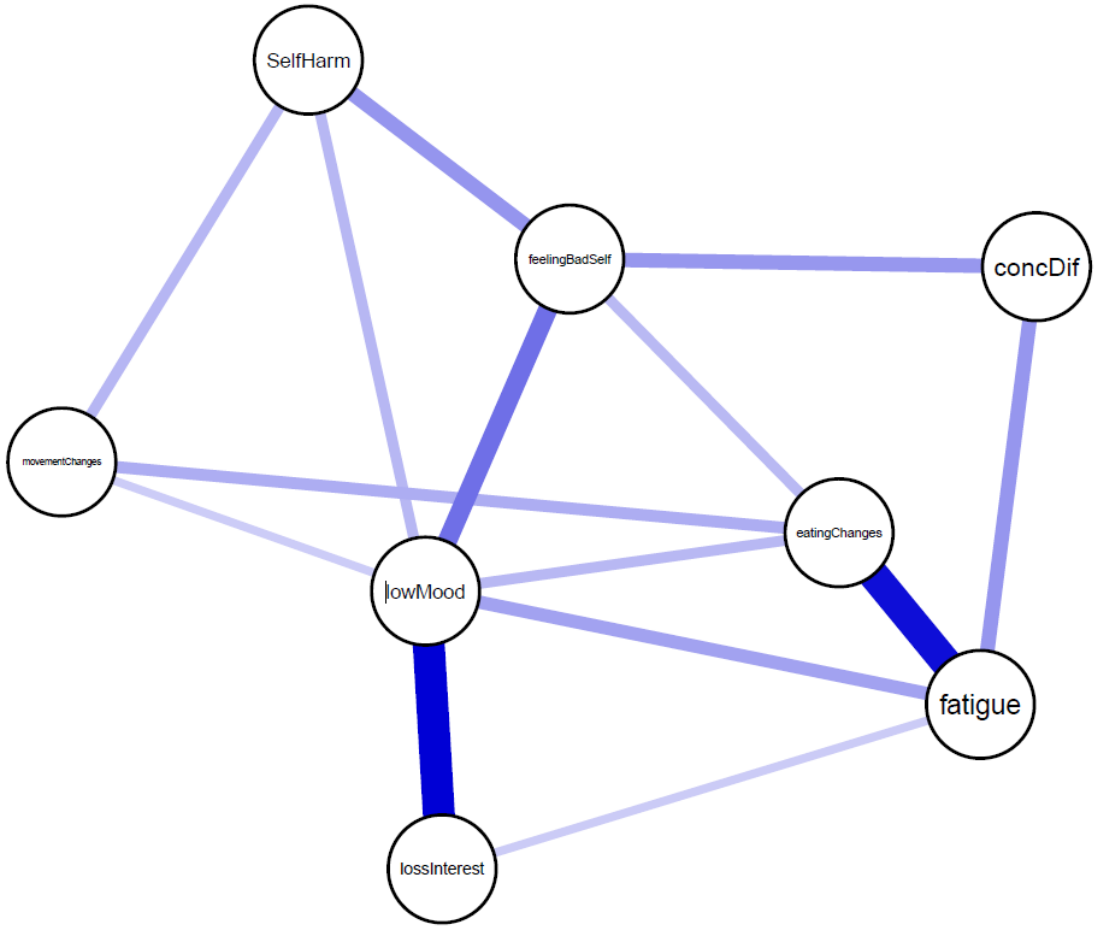

```
Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.100130   0.193395   5.688 3.34e-06 ***
BeepVar     -0.034955   0.009406  -3.716 0.000827 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Item inclusion/exclusion and ESM

- Goes without saying – a network can only represent what we include in it.
- Some critical elements were not included, and we are not seeing the full picture.
- **This is ALWAYS true!**
- Conversely – item inclusion might also be an issue
- Typically sleep is left out (observations nested in days nested in individuals)
- Can’t account for this structure in these models
- For the presented network I left it in
- The question was ‘since the last time we asked have you had trouble sleeping, or too much sleep’.
- Daytime sleeps may well be considered ‘too much sleep’.

Without sleep….





Structure mostly unchanged

Temporal

- Highest out-strength – Eating changes
- Highest in-strength – Concentration difficulties and then fatigue

Contemporaneous

- Highest strength – feeling down, depressed or hopeless

Measurement

Eiko Fried @EikoFried · Nov 27, 2017

10/ MDD sum scores add up not only very diverse Sx, but literal opposites (e.g. insomnia vs hypersomnia; weight gain vs weight loss; appetite again vs loss; psychomotor agitation vs retardation). From a measurement perspective, this is pretty stunning.

- Used the PHQ-9 with amended time-frame - may be just as hard to self-report
- Some of the criteria contain 'opposites' – e.g., trouble falling asleep ***or*** sleeping too much; poor appetite ***or*** eating too much
- One thing in a cross-sectional measurement, another in repeated assessments with short time frames
  - Investigating how deviations from the mean in one variable predicts deviations from a mean in another variable.
- **Auto-regression** in eating changes
  - Self-regulation (Less hungry one time, more hungry the next)?
  - Reinforcing (eating more predicts eating more)?
- We don't know because we didn't ask.
- **ESM studies in particular should ask about the direction of the change**

Conclusions regarding the networks

✓Depression symptoms are dynamic - we *should* investigate them using ESM

? Depression dynamic network may indicate:

- That deviations from the mean in eating behaviors predicts deviations from the mean in concentration difficulties and fatigue
- And that feeling worse about oneself than usual also predicts suicidal ideation/thoughts about self harm and changes in eating.

? *Or not*…

The Emperor has got no clothes?!

- Can we *really* interpret these kinds of models?
- Do they provide meaningful or useful information?
- Has the Emperor got no clothes?!

Potential

- Models have got great potential
- But, we have to exercise A LOT of caution in the application of time-series networks. Think about the issues surrounding measurement, item inclusion/exclusion, model assumptions, interpretation.
- Time-series networks more closely reflect network theory
- Can be used to generate hypotheses
- Give insight into potential causal relations
- Basis for new studies
- Emerging field – rapid developments, refreshingly self-critical. Collaborative effort to communicate and address the limitations.

Thank you for listening!

Talya Greene

Email: tgreene@univ.haifa.ac.il

Twitter: @Talyagreene

אוניברסיטת חיפה
University of Haifa
جامعة حيفا