Dynamic network analysis of depression symptoms
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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).
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)
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
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

• 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!

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