No Paradoxes
Interpreting Within- and Between-subject Network Structures

Sacha Epskamp

EAPP / EAPA Expert Meeting
The network approach has been proposed to re-conceptualize personality traits as clusters in a network of interacting components.


From this idea new exploratory data analysis tools (network psychometrics) have been developed which visualize variation in a dataset as networks.


A prominent topic of discussion in network psychometrics is what the source of data should be (cross-sectional vs time-series analysis).

This talk will discuss apparent paradoxes that may arise as well as empirical investigations to the overlap between within- and between-subject network structures.
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Cross-sectional Analysis

- Multiple people measured once: *cross-sectional analysis*
Cross-sectional research: A single snapshot
Cross-sectional Analysis

- **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.

- **Concentration network**: conditional association between two variables
Time-series data

- Multiple people measured once: *cross-sectional analysis*
- One person measured multiple times: $N = 1$ *time-series*
- Multiple people measured multiple times: $N > 1$ *time-series*
Cattell’s data box
Time-series Analysis

- Per subject (and fixed effects): temporal and contemporaneous networks
  - Relationships between deviations from the means
- Between-subjects network: concentration network between stationary means
  - Relationships between the means
Temporal network

Exercising → Energetic

Contemporaneous network

Exercising → Energetic
Cross-sectional Data

• Only under unrealistic assumptions do cross-sectional results align with time-series results (see Molenaar, 2004).

• A lot of criticism towards cross-sectional network analysis because of this.

• "[T]he utility of cross-sectional psychopathology networks fundamentally relies on the assumption of ergodicity: that the between-person structure at one time is the same as the within-person structure over time (Molenaar, 2004)" — Forbes et al. (in press).

• "We think it is time to investigate networks at the proper level of investigation (i.e., at the intraindividual level). As long as we keep investigating cross-sectional group-level networks, the results will remain compatible with a traditional disease model, will not be informative of symptom interactions within individuals, and will obscure scientific reasoning" — Bos & Wanders (2016).

• "If both [cross-sectional GGM and temporal VAR] result in similar conclusions, this would greatly facilitate future research and clinical applications (...). If not, then cross-sectional symptom networks are unlikely to reflect causal symptom dynamics, as postulated by this network theory." — Bos et al. (2017).
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Slide by Ellen Hamaker
Cross-sectional research: A single snapshot
But what is a cross-sectional network really?
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- Mathematically, a mixture of within- and between-subject networks *if* the cross-sectional dataset is equal to a snapshot in time-series analysis
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- No reason to expect these to align with time-series results

"Don't throw the baby out with the bathwater" — Angelique Cramer (APS 2018)
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Simulation Study

- Generated data under chain graph within-person network and random graph between-person network
  - Edges set to 0.25 and made negative with 50% probability
- Relative within-person SD to between-person SD 0.1, 0.2, 0.5, 1, 2, 5 or 10
- Simulate cross-sectional dataset (within + between), and estimate network model using `ggmModSelect`
Empirical studies to cross-sectional data

a: first observation network \((n = 104)\); person-mean network \((n = 104)\); c: the dynamic network \((n = 104 \times 50)\)

Based on the work of Bos et al. (2017), my student Alex Alvarez Perez investigated empirical overlap between within- and between-subject effects in three datasets:


Models estimated using *mlVAR* and compared on correlation between edge parameters (after rescaling reverse coded items) for each dataset, 1000 generated cross-sectional datasets by taking one measurement at random for each subject, analyzed using *ggmModSelect* from *qgraph*.
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  - Analyzed using *ggmModSelect* from qgraph
Bringmann et al. data
Bringmann et al. data

Temporal

Con temporaneous

Between−subjects
Bringmann et al.
Edge correlation

<table>
<thead>
<tr>
<th></th>
<th>Temporal</th>
<th>Contemporaneous</th>
<th>Between–subjects</th>
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<tr>
<td>Cheerful</td>
<td><img src="temporal_cheerful.png" alt="Network Diagram" /></td>
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<td>Sad</td>
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<td><img src="image15" alt="Between–subjects Relaxed" /></td>
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- **Temporal**:
  - 25 (100%)
  - Total: 25 & 25

- **Contemporaneous**: 9 (81.82%)
  - Total: 11 & 12

- **Between–subjects**: 6 (75%)
  - Total: 11 & 8

- **Temporal**: 9 (81.82%)
  - Total: 12 & 11

- **Contemporaneous**: 12 (100%)
  - Total: 12 & 12

- **Between–subjects**: 7 (87.5%)
  - Total: 12 & 8

- **Temporal**: 6 (75%)
  - Total: 8 & 11

- **Contemporaneous**: 7 (87.5%)
  - Total: 8 & 12

- **Between–subjects**: 8 (100%)
  - Total: 8 & 8
Bringmann et al.
Shared zeroes

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<td></td>
<td><strong>11 (100%)</strong></td>
<td><strong>1 (33.33%)</strong></td>
<td><strong>2 (50%)</strong></td>
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<td>Total:</td>
<td>11 &amp; 11</td>
<td>4 &amp; 3</td>
<td>4 &amp; 7</td>
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<td><strong>1 (33.33%)</strong></td>
<td><strong>3 (100%)</strong></td>
<td><strong>2 (66.67%)</strong></td>
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<td><strong>2 (50%)</strong></td>
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### “Cross-sectional” results

<table>
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<tr>
<th>Edge correlation</th>
<th>proprportion shared edges</th>
<th>Proportion shared missings</th>
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<td>Between-subjects</td>
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<tr>
<td>0.00</td>
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*Bringmann et al. data*
Wright et al. data
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<td><strong>Contemporaneous</strong></td>
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<td>Time Period</td>
<td>Count (%)</td>
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<td></td>
<td>11 (100%)</td>
<td>Total: 11 &amp; 11</td>
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<td></td>
<td>5 (100%)</td>
<td>Total: 5 &amp; 14</td>
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<td></td>
<td>4 (80%)</td>
<td>Total: 5 &amp; 8</td>
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<td><strong>Contemporaneous</strong></td>
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<td></td>
<td>5 (100%)</td>
<td>Total: 14 &amp; 5</td>
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“Cross-sectional” results
Mottus et al. data
Mottus et al. data

Temporal

Contemporaneous

Between−subjects
Mottus et al.  
Edge correlation

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“Cross-sectional” results
Conclusion

Network analysis can be used to gain exploratory insight in temporal, contemporaneous, and between-subject effects. All three can give valuable insight and may even lead to generating hypotheses for expected effects under interventions. Seemingly paradoxical results can usually be explained with interpretation of different sources of variation. Take the method of data gathering into account when interpreting cross-sectional results. May often allow for between-subjects interpretation. No theoretical reason to expect overlap between within- and between-subject results. But empirical studies do show sizeable overlap between within- and between-subject results.
Conclusion

- Network analysis can be used to gain exploratory insight in \textit{temporal}, \textit{contemporaneous}, and \textit{between-subject} effects
Conclusion

• Network analysis can be used to gain exploratory insight in *temporal, contemporaneous, and between-subject* effects
  • All three can give valuable insight and may even lead to generate hypothesis to expected effects under interventions

• Seemingly paradoxical results can usually be explained with interpretation of different sources of variation

• Take method of data gathering into account when interpreting cross-sectional results

• May often allow for between-subjects interpretation

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Thank you for your attention!

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