Formal Theories in Psychology:

What they are, Why they matter
How to build them

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Getting to know each other

- Who are you?
- What brought your here?
- What are your expectations?

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What psychological theories do you work with in your research?
`https://www.wooclap.com/HTIJJT`

Psychology has a theory problem

"Theories in "soft" areas of psychology lack the cumulative character of scientific knowledge. They tend neither to be refuted nor corroborated, but instead merely fade away as people lose interest [...] the excessive reliance on significance testing is partly responsible, being a poor way of doing science [...] "

"[...] we must carefully distinguish substantive theory from statistical hypothesis. There is a tendency in the social sciences to conflate these in talking about our inferences."

- Paul E. Meehl (1978)

The Theory Problem

Theories are often (practically) absent in much of empirical psychology. Over-reliance on statistical modeling and statistical hypothesis testing **divorced from theory**

Theories that do exist are typically **vague**. They make no precise predictions, so it's unclear how we can use them or test them with our statistical machinery

As a result, theories do not progress and are not developed further

Formalizing theory as a mathematical or computational model

- Forces us to be explicit and specific about our theoretical expectations
- Allows a common basis on which to build a cumulative body of theory
- Clarifies the role of statistical modeling in supporting theory development

(Robinaugh et al., 2019; Haslbeck* ,Ryan* ,Robinaugh*, et al., 2021; Robinaugh et al. 2021; Oberauer & Lewandowsky 2019; Smaldino 2017; Borsboom et al. 2020; Guest & Martin 2020; van Rooij & Baggio 2020; Fried 2020)

Schedule for today

- **10:00-11:15:** Why Formal Theory?
- **11:15-11:30:** (Break)
- **11:30-13:00:** Target Systems & Phenomena: First Step Toward Formal Theory
- **13:00-14:30:** (Lunch)
- **14:30-16:00:** Formalizing Theories with Difference Equations
- **16:00-16:15:** (Break)
- **16:15-17:00:** Developing Formal Theories & Conclusion

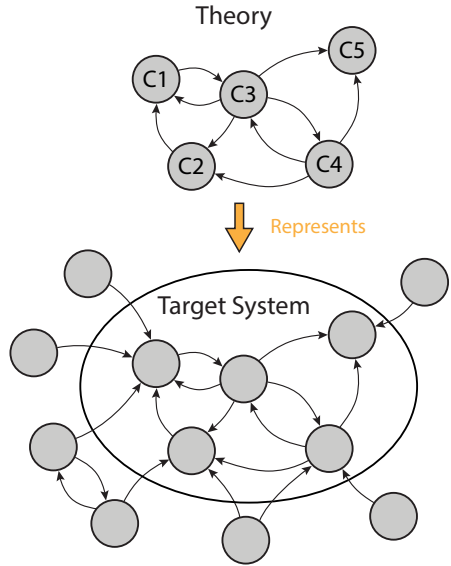
What are theories?

Theories explain *phenomena*: Stable features of the real world

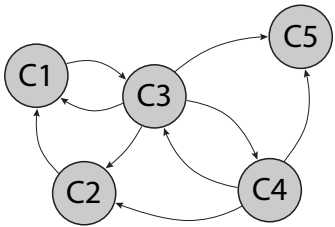
Target System: The parts of the real world that give rise to the phenomena

Theories allow for *surrogative reasoning*

- Explanation, prediction and control



Theory



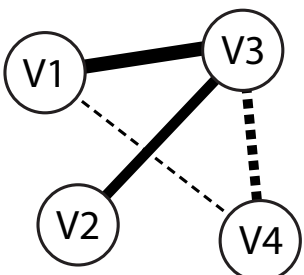
The core goal of any substantive science is a good theory

- The more precise and specific the theory is, the better our surrogate reasoning
- Vague theories can neither be refuted nor corroborated

Data

V1	V2	V3	V4
1.58	3.00	2.47	4.01
2.83	6.13	4.89	2.33
4.82	3.46	6.73	5.44
0.64	5.72	3.91	2.54
5.11	4.49	2.27	4.03

Data Model



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Data is.... Empirical Data

- Measurements / observations of the real world
- Cross-sectional surveys
- Time-series (e.g. ESM)
- Actigraphy / physiological measurements
- Eye-tracking
- etc. etc.

Statistical models which:
a) can be estimated from empirical data
b) capture some features in that data

- Correlation coefficient
- 2 x 2 contingency table
- Linear regression
- SEM, IRT
- Network models, Mixture models

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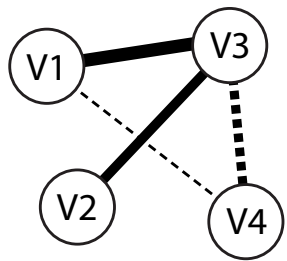

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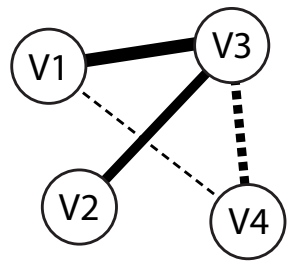
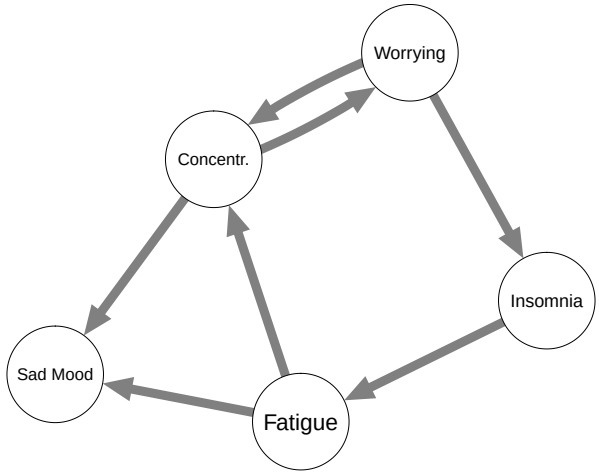


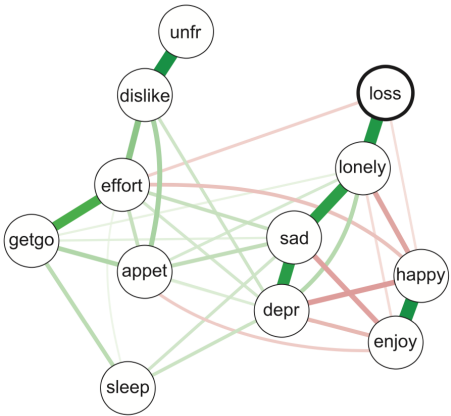
Data models are not equivalent to or replacements of theories

Network Approach to Psychopathology



(Cramer at al, 2010; Borsboom et al. 2013; Schmittman et al, 2013; Borsboom, 2017)

Statistical Network Analysis



(Figure from Fried et al., 2015)

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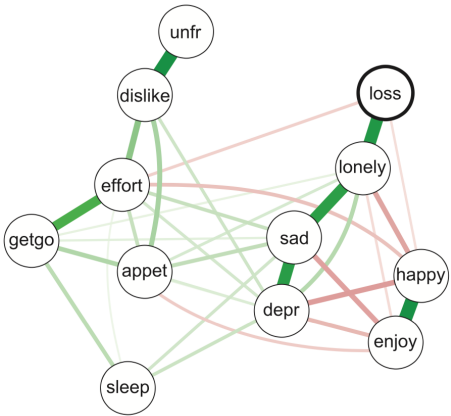

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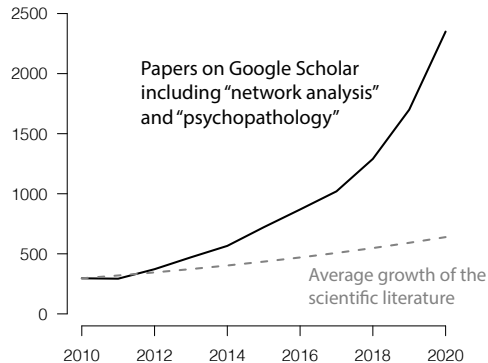
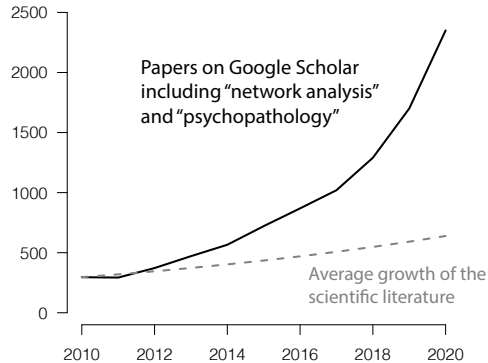


Statistical Network Analysis

Theories?



What are Phenomena?

Theories aim to explain *phenomena*: Stable features of the real world

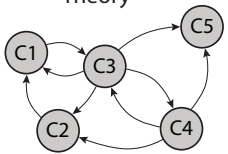
- The melting point of lead, orbit of planets
- The tendency for some people to exhibit panic attacks, concurrent with excessive worry about future attacks

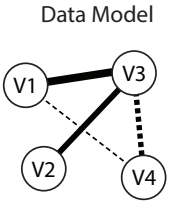
Data models could be considered *phenomena*

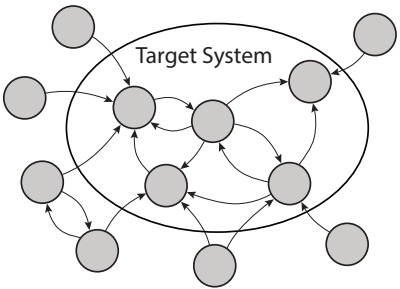
- But only those models which are particularly robust and replicable
- A phenomenon does not have to be a statistical model!

The hardest phenomenon to explain is one that doesn't exist (Lakatos, 1991)

Target systems, Theories, Data and Data Models







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(Suárez & Pero, 2019; Haslbeck* ,Ryan* ,Robinaugh*, et al., 2021)