Exploratory network analysis of the French Wechsler Intelligence Scale for children-Fourth Edition (WISC-IV)

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Abstract
Evidence of the factorial structure of the Wechsler Intelligence Scale for Children-Fourth Edition was established through Exploratory and Confirmatory Factor Analyses. Recently, network models have been developed as an alternative way of assessing factorial structure. The network approach assumes that cognitive ability results from the causal interplay between processes involved in subtests scores and focuses on these subtests and their complex associations. The WISC-IV network was analyzed through the correlations between 11 subtests scores. Participants included 483 French-speaking Swiss children. Although network model supported a four-factor structure, this four-factor structure did not correspond to the expected saturated partial correlation network, challenging the existence of the general factor of intelligence. Network approach allows assessing the centrality of each subtest, and indicated that vocabulary and similarities are the two most central subtests in the network, while Coding was the most peripheral one’s.

Reference

Available at:
http://archive-ouverte.unige.ch/unige:98494

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INTRODUCTION

- Exploratory and Confirmatory Factor Analysis are frequently used to uncover underlying latent variables that explain the structural covariation in the data.
- WISC-IV: 4 latent variables are considered to be responsible of the structural covariation between subtest scores: Verbal Comprehension [VC], Perceptual Reasoning [PR], Processing Speed [PS], and Working Memory [WM].
- The psychometric network modeling suggests to move away from the latent variable perspective, and considers that dimensions arise from the interactions between entities in a network.
- Network includes nodes (psychological variables) connected by edges (statistical relationships).
- Models focused on the estimation of direct relationships between observed variables.

OBJECTIVE

- Analysis of the structure of the French WISC-IV by applying a network approach.
  - Estimation of the number of dimensions underlying the WISC-IV using network psychometrics.
  - Estimation of the network; edges represent the relations between the subtests of the WISC-IV.
  - Estimation of the centrality of each variable, to determine the overall connectivity of a subtest, and the importance of each score.

METHOD

- Sample: 483 French-speaking Swiss children aged from 7 to 12 years. The sample included 230 males (mean age = 9.50, SD=1.30) and 253 females (mean age = 9.54, SD=1.29).

- Material: The 10 core subtests of the WISC-IV and the optional subtest Picture Completion were administered to children (PC was not administered to 19 children).

<table>
<thead>
<tr>
<th>VC: Verbal Comprehension</th>
<th>PR: Perceptual Reasoning</th>
<th>WM: Working Memory</th>
<th>PS: Processing Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Si: Similarities</td>
<td>BD: Block Design</td>
<td>DS: Digit Span</td>
<td>CD: Coding</td>
</tr>
<tr>
<td>VO: Vocabulary</td>
<td>MR: Matrix Reasoning</td>
<td>LN: Letter-number</td>
<td>SS: Symbol Search</td>
</tr>
<tr>
<td>CO: Comprehension</td>
<td>PC: Picture Concepts</td>
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<td></td>
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<tr>
<td></td>
<td>(PC: Picture Completion)</td>
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</tbody>
</table>

- Analyses: Within the network approach, we used the R-package *exploratory graph analysis* (EGA) to estimate the number of dimensions.
- A Gaussian Graphical Model (GGM) was used to model the undirected network between subtests. Centrality indices were computed from the network.
- In GGM, an edge is the partial correlations between 2 variables, controlling for all other associations in the network.
- We used the R-package *qgraph* that includes the LASSO regularization to return a sparse network model.
- We used the R-package *bootnet* to assess the stability of the network structure and centrality indices.

RESULTS

1. Estimation of the number of dimensions

- EGA suggested to retain 4 dimensions.
- Green lines = positive correlations
- Thicker edge = larger correlation

2. Network structure (with significant edges only)

- Four clusters emerged: VC (Si, VO, CO); WM (LN, DS); PS (SS, CD); and VisuoSpatial (VS with BD, PC, MR)
  - Cluster : group of connected nodes
  - PCo is related with VC, WM, and VS.

- Centrality indices
  - Betweenness: how many shortest paths between 2 nodes go through the node in question. Includes direct and indirect connections of a subtests. A subtest with high betweenness is more important in connecting nodes.
  - Closeness: how strongly a node is indirectly connected to other nodes in the network.
  - Node strength: how strongly a node is directly connected to other nodes in the network.

CONCLUSIONS

- Network approach conceptualizes psychological dimensions as networks of psychological variables that directly interact with one another (without assuming a latent variable).
- Exploratory Graph Analysis (EGA) revealed 4 clusters.
- The clusters of nodes VC, WM, and PS in the network are equal with the 3 latent variables with factor analysis. Network analysis showed that the fourth dimension is more “VisuoSpatial” than “Perceptual Reasoning”.
- The three most central node in the network are Similarities, Vocabulary and Block Design. This finding is partially consistent with factor analysis that showed that g loadings of Similarities and Vocabulary tasks were the highest.
- In sum, broad abilities and general intelligence can be conceptualized as networks of basic components.

Thicker edge = larger correlation

Node strength: how strongly a node is directly connected to other nodes in the network.