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

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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.

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>PCo: Picture Concepts</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(PC: Picture Completion)</td>
<td></td>
<td></td>
</tr>
</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 ggraph 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.