The bifactor package

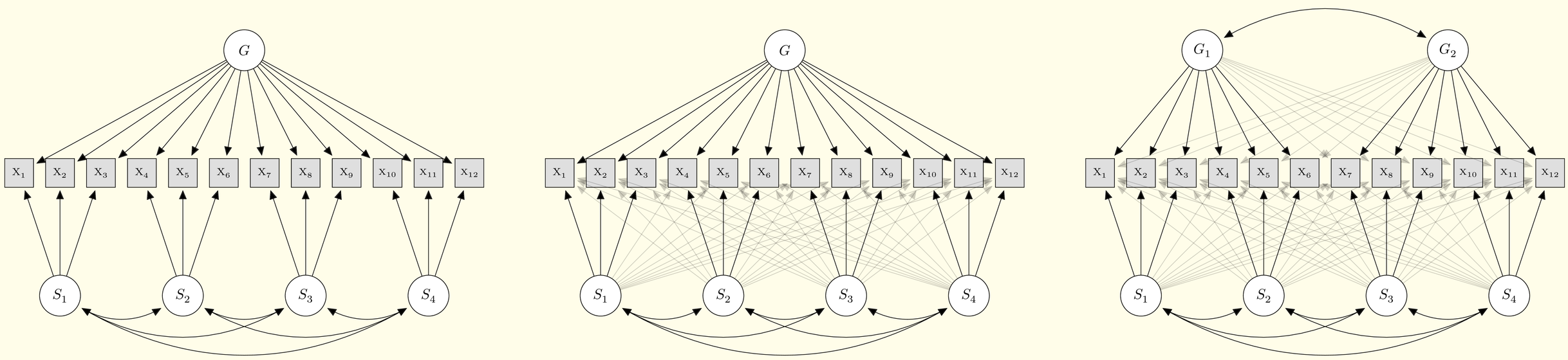
Marcos Jiménez [1] Francisco J. Abad [1] Eduardo Garcia-Garzon [2]
Luis E. Garrido [3] [4] Vithor R. Franco

[1] Universidad Autónoma de Madrid, Spain [2] Shakers, Spain
[3] Pontificia Universidad Católica Madre y Maestra, Dominican Republic
[4] Universidade São Francisco, Brazil

Available methods: Bifactor Analyses and beyond

Simple Models ..... **Complex Models**

Confirmatory Bi-factor | **Exploratory Bi-factor** | **Multiple General Factors (Exploratory)**



CFA functions

`cfast(data, model, estimator, ...)`

model: Specify any kind of model and constraint
estimator: ML, ULS, GLS, DWLS

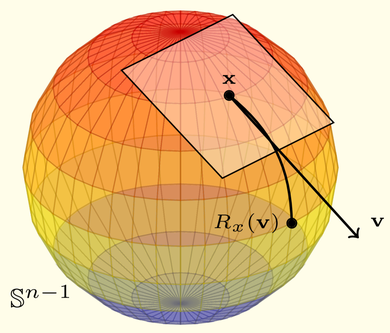
EFA functions

`efast(data, nfactors, estimator, rotation, projection, ...)`
`bifactor(data, nfactors, estimator, projection, ...)`
`rotate(lambda, rotation, projection, ...)`

estimator: ML, ULS, GLS, DWLS
rotation: Oblimin, Geomin, Target, Crawford-Ferguson, Bi-quartimin, Bi-geomin, etc.
projection: Orthogonal, Oblique, **Partially Oblique (New rotation only in `bifactor`!)**

Proper model identification

Constrained Optimization on Manifolds



The Partially Oblique Manifold

A square matrix $\mathbf{\Phi}$ is parametrized as $\mathbf{X}^\top\mathbf{X}$ to **ensure positive semi-definiteness** but specific cells in $\mathbf{\Phi}$ are constrained to be zero.

The Role of Partially Oblique Rotation in EFA

- In **Bifactor models**, the general factors must be **uncorrelated** with the specific factors to obtain an interpretable solution.
- In **Multitrait-Multimethod designs**, the trait factors must be **uncorrelated** with the method factors.
- The `rotate` function achieves these goals thanks to the **partially oblique rotation**.

`warning: covariance matrix of latent variables is not positive definite`

- Using the `cfast` function, no warning messages will pop up for confirmatory factor analyses!
- With the **partially oblique manifold**, the matrices will always be, at least, positive semidefinite.

Extremely Fast Convergence

Polychorics estimation

`polyfast(X, cores, ...)`

- **Thousands of times faster** than popular alternatives thanks to its **C++ implementation**.
- Estimation of the correlations between hundreds of variables **in very few seconds**.
- Even faster if **parallelizing** with the `cores` argument.
- **No need for smoothing**. The solution is always, at least, positive semidefinite.
- Use the function `parallel` for fast parallel analysis with polychorics.

EFA estimation

`efast(data, nfactors, estimator, rotation, projection, cores, ...)`

- **Very fast rotation** thanks to Newton-based optimization routines and **C++ implementation**.
- Arbitrary number of random starts to **avoid local minima** in the rotation.
- **Parallelization** of the random starts with the `cores` argument.
- **No Heywood cases**.
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Additional Features and Next Developments

Additional Features

- SEM features: **Multigroup estimation (invariance) and correlated errors** for both confirmatory and exploratory models.
- Standard errors robust to non-normality and population error.
- **Mixed rotations**: In EFA, different rotation criteria can be combined or applied to different items and factors.
- Fit indices, reliability, and indeterminacy values available for all fitting functions.
- Simulation of realistic and complex structures with population error with the `sim_factor` function.

RoadMap

- Expanding the `cfast` and `efast` functions to the SEM and ESEM frameworks: latent regressions, outcomes, predictors, etc.
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