lsttheory: An R Package for Fast Computation of State Trait Models

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Abstract

This R (?, ?) package is a supplement for the article 'A Theory of States and Traits' (Steyer, Geiser, Cole, & Mayer, 2013). It is based on the structural equation modeling R package lavaan (Rosseel, 2012) and provides a convenient interface to compute some common models of the revised latent state-trait theory (LST-R theory). The main function of the package allows for easy specification of multistate, multistate-singletrait, and multistate-multitrait models. It automatically generates lavaan syntax for these models, runs the models, and returns model estimates together with reliability, occasion specificity, and consistency coefficients for the respective models. There is also an additional package called lsttheoryGUI, which depends on lsttheory. The lsttheoryGUI provides a graphical user interface, i.e., a click menu, for users who are not familiar with R. lsttheoryGUI works best with the JGR console for R (Markus Helbig, Simon Urbanek, & Ian Fellows, 2013).

Keywords: states, traits, reliability, occasion specificity, consistency

Cautionary Note: The package is currently under development and some things may change in the future. We are at an early stage of development and it is likely that the structure and key aspects of the two packages will change. The latest versions can be downloaded from metheval.uni-jena.de. We also plan to release the package on CRAN, once we are a bit furhter in the develpment process. Please report any bugs.

Contents

1 Introduction

lsttheory allows for easy specification of multistate, multistate-singletrait, and multistate-multitrait models. This vignette is structured as follows: We first describe the installation process in detail for nonexperienced users of R. Users who are familiar with package installation from local .zip files may wish to skip this section. We then present various kinds of LST-R theory models with syntax and model results.

2 Installation

The R package lsttheory will most likely be installed from a local file. Therefore, we need to install the dependencies first. The installation has been tested under Windows 7 and under Linux (Ubuntu 11.10). It should also work under Mac OS X using the JGR console — but we haven't tested it yet. Please make sure that you are using R version 3.0.1 or higher.

2.1 Windows Installation

For a Windows installation (without Rtools) we suggest installing the dependencies from a CRAN mirror first by executing

```
install.packages("lavaan")  ## for lsttheory
install.packages("Deducer")  ## for lsttheoryGUI
```

in the console (either the standard Rconsole or the JGR console) and then selecting a mirror next to you. After that, the R package lsttheory can be installed using the Windows binary file (with file ending .zip) as follows:

```
install.packages("D:/workspace/lsttheory_0.1-1.zip")
install.packages("D:/workspace/lsttheoryGUI_0.1-1.zip")
```

Please adjust the file path and version number accordingly. We recommend using the JGR console (http://rforge.net/JGR/). The JGR console can be called via a launcher or from with an R session by calling

```
library(JGR)
JGR()
```

2.2 Linux Installation

We assume that Linux users are familiar with installing R packages from source. The source files are lsttheory_0.1-1.tar.gz and lsttheoryGUI_0.1-1.tar.gz.

Note that for the graphical user interface to work, the user may want to use the JGR console. The JGR console can be called from with an R session by calling

```
library(JGR)
JGR()
```

2.3 Loading the Package

After having succesfully installed the packages, we need to load them:

```
library("lsttheory")

## Loading required package:  lavaan
## This is lavaan 0.5-16
## lavaan is BETA software!  Please report any bugs.

# library('lsttheoryGUI')
```

If you are using the JGR console, you can click on default next to the lsttheory and lsttheoryGUI entry in the Package Installer. Then the packages and their dependencies are automatically loaded every time you open JGR.

3 Multistate Models

The lsttheory pacakge contains several simulated example datasets. The first one that we use is the dataset `multistate`. It contains 9 manifest variables Y_{it}, where the index refers to the ith manifest variable assessed at occasion t.

```
data(multistate)
head(round(multistate, 2))

##     y11   y21   y31   y12   y22   y32   y13   y23   y33
## 1  3.88  4.76  4.54  3.95  5.68  2.53  2.18  3.74  3.29
## 2  0.02  2.40  2.42  2.52  3.33  0.33  0.08  1.61  0.83
## 3  0.06  1.54 -0.86  0.12 -1.19  1.69  1.59  2.49  0.20
## 4  2.70  3.41  3.31  2.63  1.83  3.29  2.47  2.05  3.34
## 5  0.30  2.03 -0.08  0.46  1.41  1.19 -1.58 -1.40  0.97
## 6 -5.13 -3.78 -3.23 -0.34  1.48 -1.64 -2.36 -3.27 -0.78
```

3.1 Multistate Model with η_t-Congenericity

First, we use this dataset to fit a multistate model with η_t-congenericity and conditional mean independence (see Box 4.1 of SGCM). The main function of our package to be called by the user is `lsttheory`. See `?lsttheory` for details. It is used to fit all models. The multistate model with η_t-congenericity can be specified as follows:

```
m1 <- lsttheory(neta = 3, data = multistate)
print(m1)

##
##  Multistate Model
##
##     rely spey cony
## y11 0.73   NA   NA
## y21 0.83   NA   NA
## y31 0.64   NA   NA
## y12 0.77   NA   NA
## y22 0.81   NA   NA
## y32 0.65   NA   NA
## y13 0.74   NA   NA
## y23 0.79   NA   NA
## y33 0.68   NA   NA
##
##
```

The lsttheory function just requires two mandatory arguments: The number of common state variables η_t and the dataset to use. In the current version of our package, the dataset may only include the manifest variables Y_{it} and these should be ordered by occasion t and indicator i, i.e., $Y_{11}, Y_{21}, \ldots, Y_{12}, Y_{22}, \ldots, Y_{13}, Y_{23}, \ldots$. The lsttheory function returns an object of class lsttheory for which several methods are available. `print(m1)` shows reliability, occasion specificity, and consistency coefficients (see Box 3.1 of SGCM). For the multistate model only reliability coefficients are available, because traits are not modeled.

The function lsttheory has automaticall generated lavaan input syntax:

```
cat(m1@lavaansyntax)
```

```
## eta1 =~ 1*y11
## eta1 =~ la211*y21
## eta1 =~ la311*y31
## eta2 =~ 1*y12
## eta2 =~ la221*y22
## eta2 =~ la321*y32
## eta3 =~ 1*y13
## eta3 =~ la231*y23
## eta3 =~ la331*y33
## y11 ~ 0*1
## y21 ~ la210*1
## y31 ~ la310*1
## y12 ~ 0*1
## y22 ~ la220*1
## y32 ~ la320*1
## y13 ~ 0*1
## y23 ~ la230*1
## y33 ~ la330*1
## eta1 ~ ga10*1
## eta2 ~ ga20*1
## eta3 ~ ga30*1
## y11 ~~ eps11*y11
## y21 ~~ eps21*y21
## y31 ~~ eps31*y31
## y12 ~~ eps12*y12
## y22 ~~ eps22*y22
## y32 ~~ eps32*y32
## y13 ~~ eps13*y13
## y23 ~~ eps23*y23
## y33 ~~ eps33*y33
## eta1 ~~ psi1*eta1
## eta2 ~~ psi2*eta2
## eta3 ~~ psi3*eta3
##
```

```
##
##
##
## vareta1 := psi1
## vareta2 := psi2
## vareta3 := psi3
## vary11 := 1^2 * vareta1 + eps11
## vary21 := la211^2 * vareta1 + eps21
## vary31 := la311^2 * vareta1 + eps31
## vary12 := 1^2 * vareta2 + eps12
## vary22 := la221^2 * vareta2 + eps22
## vary32 := la321^2 * vareta2 + eps32
## vary13 := 1^2 * vareta3 + eps13
## vary23 := la231^2 * vareta3 + eps23
## vary33 := la331^2 * vareta3 + eps33
## rely11 := 1^2 * vareta1 / vary11
## rely21 := la211^2 * vareta1 / vary21
## rely31 := la311^2 * vareta1 / vary31
## rely12 := 1^2 * vareta2 / vary12
## rely22 := la221^2 * vareta2 / vary22
## rely32 := la321^2 * vareta2 / vary32
## rely13 := 1^2 * vareta3 / vary13
## rely23 := la231^2 * vareta3 / vary23
## rely33 := la331^2 * vareta3 / vary33
```

and the lavaan output can be seen by calling:

```
summary(m1@lavaanres)

## lavaan (0.5-16) converged normally after  47 iterations
##
##   Number of observations                          1000
##
##   Estimator                                         ML
##   Minimum Function Test Statistic               32.025
##   Degrees of freedom                                24
##   P-value (Chi-square)                           0.126
##
## Parameter estimates:
##
##   Information                                 Expected
##   Standard Errors                             Standard
##
##                    Estimate  Std.err  Z-value  P(>|z|)
## Latent variables:
```

```
##   eta1 =~
##     y11               1.000
##     y21    (l211)     1.221    0.034   35.656    0.000
##     y31    (l311)     0.801    0.027   30.166    0.000
##   eta2 =~
##     y12               1.000
##     y22    (l221)     1.211    0.032   37.430    0.000
##     y32    (l321)     0.772    0.024   31.867    0.000
##   eta3 =~
##     y13               1.000
##     y23    (l231)     1.233    0.035   34.906    0.000
##     y33    (l331)     0.828    0.026   31.450    0.000
##
## Covariances:
##   eta1 ~~
##     eta2              2.041    0.131   15.535    0.000
##     eta3              1.856    0.126   14.769    0.000
##   eta2 ~~
##     eta3              2.039    0.131   15.523    0.000
##
## Intercepts:
##     y11               0.000
##     y21    (l210)     0.217    0.054    4.030    0.000
##     y31    (l310)     0.570    0.044   12.812    0.000
##     y12               0.000
##     y22    (l220)     0.212    0.060    3.539    0.000
##     y32    (l320)     0.578    0.047   12.358    0.000
##     y13               0.000
##     y23    (l230)     0.262    0.055    4.779    0.000
##     y33    (l330)     0.574    0.043   13.466    0.000
##     eta1   (ga10)     0.611    0.063    9.758    0.000
##     eta2   (ga20)     1.071    0.063   17.010    0.000
##     eta3   (ga30)     0.495    0.062    7.925    0.000
##
## Variances:
##     y11    (ep11)     1.070    0.068
##     y21    (ep21)     0.874    0.079
##     y31    (ep31)     1.029    0.057
##     y12    (ep12)     0.932    0.063
##     y22    (ep22)     1.036    0.082
##     y32    (ep32)     0.956    0.053
##     y13    (ep13)     1.028    0.067
##     y23    (ep23)     1.146    0.089
##     y33    (ep33)     0.944    0.055
##     eta1   (psi1)     2.845    0.175
```

```
##     eta2   (psi2)     3.035    0.179
##     eta3   (psi3)     2.869    0.175
##
## Defined parameters:
##     vareta1           2.845    0.175   16.243    0.000
##     vareta2           3.035    0.179   16.973    0.000
##     vareta3           2.869    0.175   16.387    0.000
##     vary11            3.914    0.175   22.361    0.000
##     vary21            5.116    0.229   22.361    0.000
##     vary31            2.853    0.128   22.361    0.000
##     vary12            3.967    0.177   22.361    0.000
##     vary22            5.483    0.245   22.361    0.000
##     vary32            2.765    0.124   22.361    0.000
##     vary13            3.897    0.174   22.361    0.000
##     vary23            5.511    0.246   22.361    0.000
##     vary33            2.912    0.130   22.361    0.000
##     rely11            0.727    0.019   37.877    0.000
##     rely21            0.829    0.017   49.704    0.000
##     rely31            0.639    0.022   29.628    0.000
##     rely12            0.765    0.018   43.377    0.000
##     rely22            0.811    0.016   49.447    0.000
##     rely32            0.654    0.021   31.323    0.000
##     rely13            0.736    0.019   38.680    0.000
##     rely23            0.792    0.018   45.000    0.000
##     rely33            0.676    0.021   32.679    0.000
```

The slot lavaanres in the m1 object contains the fitted lavaan object of class lavaan. See `?"lavaan-class"` for more information and available methods.

3.2 Multistate Model with Essential η_t-Equivalence

The default setting of the lsttheory function is to assume η_t-congenericity. If we want to assume essential η_t-equivalence, we need to specify an additional argument, namely the `equiv.assumption` argument, which is a list of equivalence assumptions. For the multistate model, the xi argument will be ignored. By specifying `tau="ess"`, we assume essential η_t-equivalence:

```
m1 <- lsttheory(neta = 3, data = multistate, equiv.assumption = list(tau = "ess",
    xi = "equi"))
coef(m1@lavaanres, type = "user")

##   eta1=~y11  eta1=~y21  eta1=~y31  eta2=~y12  eta2=~y22  eta2=~y32
##       1.000      1.000      1.000      1.000      1.000      1.000
##   eta3=~y13  eta3=~y23  eta3=~y33      y11~1      la210      la310
##       1.000      1.000      1.000      0.000      0.352      0.448
```

```
##      y12~1      la220      la320      y13~1      la230      la330
##      0.000      0.438      0.334      0.000      0.378      0.489
##       ga10       ga20       ga30      eps11      eps21      eps31
##      0.611      1.071      0.495      1.064      1.375      0.962
##      eps12      eps22      eps32      eps13      eps23      eps33
##      0.993      1.563      0.891      1.083      1.674      0.831
##       psi1       psi2       psi3 eta1~~eta2 eta1~~eta3 eta2~~eta3
##      2.721      2.747      2.715      1.946      1.794      1.909
##    vareta1    vareta2    vareta3     vary11     vary21     vary31
##      2.721      2.747      2.715      3.785      4.096      3.683
##     vary12     vary22     vary32     vary13     vary23     vary33
##      3.740      4.310      3.638      3.798      4.389      3.546
##     rely11     rely21     rely31     rely12     rely22     rely32
##      0.719      0.664      0.739      0.735      0.637      0.755
##     rely13     rely23     rely33
##      0.715      0.619      0.766
```

3.3 Multistate Model with η_t-Equivalence

Similarly, if we want to assume η_t-equivalence, we specify the equivalence assumption as follows:

```
m1 <- lsttheory(neta = 3, data = multistate, equiv.assumption = list(tau = "equi",
    xi = "equi"))
coef(m1@lavaanres, type = "user")
```

```
##  eta1=~y11  eta1=~y21  eta1=~y31  eta2=~y12  eta2=~y22  eta2=~y32
##      1.000      1.000      1.000      1.000      1.000      1.000
##  eta3=~y13  eta3=~y23  eta3=~y33      y11~1      y21~1      y31~1
##      1.000      1.000      1.000      0.000      0.000      0.000
##      y12~1      y22~1      y32~1      y13~1      y23~1      y33~1
##      0.000      0.000      0.000      0.000      0.000      0.000
##       ga10       ga20       ga30      eps11      eps21      eps31
##      0.885      1.316      0.803      1.193      1.387      0.992
##      eps12      eps22      eps32      eps13      eps23      eps33
##      1.117      1.643      0.866      1.240      1.688      0.869
##       psi1       psi2       psi3 eta1~~eta2 eta1~~eta3 eta2~~eta3
##      2.705      2.696      2.697      1.936      1.798      1.898
##    vareta1    vareta2    vareta3     vary11     vary21     vary31
##      2.705      2.696      2.697      3.897      4.092      3.697
##     vary12     vary22     vary32     vary13     vary23     vary33
##      3.813      4.338      3.562      3.937      4.385      3.566
##     rely11     rely21     rely31     rely12     rely22     rely32
##      0.694      0.661      0.732      0.707      0.621      0.757
```

```
##      rely13      rely23      rely33
##       0.685       0.615       0.756
```

3.4 Multistate Models with Scale Invariance

In order to add scale invariance assumptions over time, we need to specify the scale.invariance argument. The default is not to assume scale invariance. The scale invariance argument is a list of four entries. For the multistate models, only the first and the second entry are relevant. The first entry refers to scale invariance of intercepts and the second entry refers to scale invariance of loadings. For example, if we want to specify a multistate model with η_t-congenericity and scale invariance of intercepts and loadings, the function call is:

```
m1 <- lsttheory(neta = 3, data = multistate, scale.invariance = list(lait0 = TRUE,
    lait1 = TRUE, gat0 = TRUE, gat1 = TRUE))
coef(m1@lavaanres, type = "user")

##   eta1=~y11       la211       la311   eta2=~y12       la211       la311
##       1.000       1.219       0.798       1.000       1.219       0.798
##   eta3=~y13       la211       la311       y11~1       la210       la310
##       1.000       1.219       0.798       0.000       0.229       0.570
##       y12~1       la210       la310       y13~1       la210       la310
##       0.000       0.229       0.570       0.000       0.229       0.570
##        ga10        ga20        ga30       eps11       eps21       eps31
##       0.606       1.056       0.515       1.068       0.875       1.030
##       eps12       eps22       eps32       eps13       eps23       eps33
##       0.943       1.041       0.945       1.014       1.142       0.960
##        psi1        psi2        psi3 eta1~~eta2 eta1~~eta3 eta2~~eta3
##       2.853       2.973       2.950       2.024       1.883       2.046
##     vareta1     vareta2     vareta3      vary11      vary21      vary31
##       2.853       2.973       2.950       3.922       5.116       2.847
##      vary12      vary22      vary32      vary13      vary23      vary33
##       3.916       5.459       2.838       3.964       5.526       2.838
##      rely11      rely21      rely31      rely12      rely22      rely32
##       0.728       0.829       0.638       0.759       0.809       0.667
##      rely13      rely23      rely33
##       0.744       0.793       0.662
```

Of course, the scale invariance argument can also be used for a multistate model with essential η_t-equivalence. Then, the lait1 entry is ignored.

```
m1 <- lsttheory(neta = 3, data = multistate, equiv.assumption = list(tau = "ess",
    xi = "equi"), scale.invariance = list(lait0 = TRUE, lait1 = TRUE, gat0 = TRUE,
    gat1 = TRUE))
```

For a multistate model with η_t-equivalence, all scale invariance settings are ignored.

3.5 Multistate Models with Method Factors

Section under development

4 Multistate-Singletrait Models

4.1 Multistate-Singletrait Models with θ-Congenericity

The same function lsttheory can also be used to fit multistate-singletrait models in LST-R theory. We only need to specify that there is one ξ variable[1] in addition to the specification of the corresponding multistate model. The following syntax specifies a multistate-singletrait model with the these assumptions:

- η_t-congenericity (Box 4.1 of SGCM)
- conditional mean independence (Box 4.1 of SGCM)
- θ-congenericity (Box 5.1 of SGCM)

```
m1 <- lsttheory(neta = 3, nxi = 1, data = multistate)
print(m1)

##
##  Singletrait-Multistate Model
##
##     rely spey cony
## y11 0.73 0.25 0.47
## y21 0.83 0.29 0.54
## y31 0.64 0.22 0.42
## y12 0.77 0.20 0.57
## y22 0.81 0.21 0.60
## y32 0.65 0.17 0.48
## y13 0.74 0.26 0.48
## y23 0.79 0.28 0.51
## y33 0.68 0.24 0.44
##
##
```

We now also get estimates for the occasion specificity and consistency coefficents in addition to the reliability coefficients. To see all parameters of the model:

```
coef(m1@lavaanres, type = "user")

## eta1=~y11     la211     la311 eta2=~y12     la221     la321 eta3=~y13
##     1.000     1.221     0.801     1.000     1.211     0.772     1.000
##     la231     la331     y11~1     la210     la310     y12~1     la220
##     1.233     0.828     0.000     0.217     0.570     0.000     0.212
##     la320     y13~1     la230     la330     eta1~1      ga20      ga30
```

[1]The names of the variables will be changed to be in line with SGCM

```
##     0.578     0.000     0.262     0.574     0.000     0.400    -0.115
##     eps11     eps21     eps31     eps12     eps22     eps32     eps13
##     1.070     0.874     1.029     0.932     1.036     0.956     1.028
##     eps23     eps33      psi1      psi2      psi3 xi1=~eta1      ga21
##     1.146     0.944     0.988     0.792     1.014     1.000     1.099
##      ga31    varxi1      mxi1   vareta1   vareta2   vareta3    vary11
##     0.999     1.857     0.611     2.845     3.035     2.869     3.914
##    vary21    vary31    vary12    vary22    vary32    vary13    vary23
##     5.116     2.853     3.967     5.483     2.765     3.897     5.511
##    vary33    rely11    rely21    rely31    rely12    rely22    rely32
##     2.912     0.727     0.829     0.639     0.765     0.811     0.654
##    rely13    rely23    rely33    spey11    spey21    spey31    spey12
##     0.736     0.792     0.676     0.252     0.288     0.222     0.200
##    spey22    spey32    spey13    spey23    spey33    cony11    cony21
##     0.212     0.171     0.260     0.280     0.239     0.474     0.541
##    cony31    cony12    cony22    cony32    cony13    cony23    cony33
##     0.417     0.565     0.599     0.483     0.476     0.512     0.437
```

4.2 Multistate-Singletrait Models with θ-Equivalence

We don't show all possible combinations of assumptions. We just give one more example of a multistate-singletrait model with this set of assumptions:

- essential η_t-equivalence (Box 4.1 of SGCM)
- scale invariance over time
- conditional mean independence (Box 4.1 of SGCM)
- θ-equivalence (Box 5.1 of SGCM)

```
m1 <- lsttheory(neta = 3, nxi = 1, data = multistate, equiv.assumption = list(tau = "ess",
    xi = "equi"), scale.invariance = list(lait0 = TRUE, lait1 = TRUE, gat0 = TRUE,
    gat1 = TRUE))
coef(m1@lavaanres, type = "user")
```

```
## eta1=~y11 eta1=~y21 eta1=~y31 eta2=~y12 eta2=~y22 eta2=~y32 eta3=~y13
##     1.000     1.000     1.000     1.000     1.000     1.000     1.000
## eta3=~y23 eta3=~y33     y11~1     la210     la310     y12~1     la210
##     1.000     1.000     0.000     0.385     0.421     0.000     0.385
##     la310     y13~1     la210     la310    eta1~1    eta2~1    eta3~1
##     0.421     0.000     0.385     0.421     0.000     0.000     0.000
##     eps11     eps21     eps31     eps12     eps22     eps32     eps13
##     1.064     1.381     0.961     1.004     1.591     0.878     1.090
##     eps23     eps33      psi1      psi2      psi3 xi1=~eta1 xi1=~eta2
```

```
##     1.673     0.831     0.861     0.939     0.963     1.000     1.000
## xi1=~eta3    varxi1      mxi1   vareta1   vareta2   vareta3    vary11
##     1.000     1.855     0.727     2.716     2.794     2.817     3.780
##    vary21    vary31    vary12    vary22    vary32    vary13    vary23
##     4.097     3.677     3.797     4.384     3.672     3.908     4.490
##    vary33    rely11    rely21    rely31    rely12    rely22    rely32
##     3.648     0.719     0.663     0.739     0.736     0.637     0.761
##    rely13    rely23    rely33    spey11    spey21    spey31    spey12
##     0.721     0.627     0.772     0.228     0.210     0.234     0.247
##    spey22    spey32    spey13    spey23    spey33    cony11    cony21
##     0.214     0.256     0.246     0.214     0.264     0.491     0.453
##    cony31    cony12    cony22    cony32    cony13    cony23    cony33
##     0.504     0.488     0.423     0.505     0.475     0.413     0.508
```

5 Multistate-Doubletrait Models

For the mulistate doubletrait models, we need to use a different data set, because we need at least two common state variables for each of the θ variables. The simulated data set is called `multitraitmultistate` and contains 8 manifest variables Y_{it} distributed across 4 occasions of measurement:

```
data(multitraitmultistate)
head(round(multitraitmultistate, 2))

##     y11   y21   y12   y22   y13   y23   y14   y24
## 1  1.55  1.99  0.63  0.02  1.61  2.26  4.85  3.55
## 2  1.92  3.43 -0.66 -0.58  2.81  4.27  1.58  0.97
## 3 -0.07  0.32  1.81  1.83  1.73  4.05  0.70  2.93
## 4 -0.67 -1.67  1.01  1.55 -1.79 -2.35 -0.67  0.79
## 5  0.53  0.65  0.11 -0.47 -1.10 -1.03  2.91 -0.56
## 6 -1.90 -2.47  1.46  3.04  1.02 -0.08  0.88  1.39
```

5.1 Multistate-Doubletrait Models with θ_1, θ_2-Congenericity

The first model that we want to show with this dataset is a multistate-doubletrait model with these assumptions:

- η_t-congenericity (Box 4.1 of SGCM)
- conditional mean independence (Box 4.1 of SGCM)
- θ_1-congenericity (Box 6.1 of SGCM)
- θ_2-congenericity (Box 6.1 of SGCM)

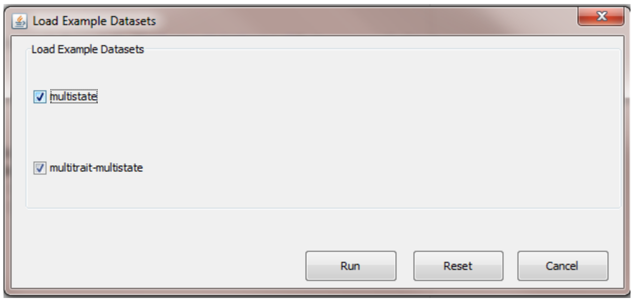
The model syntax is:

```
m1 <- lsttheory(neta = 4, nxi = 2, data = multitraitmultistate)
coef(m1@lavaanres, type = "user")

## eta1=~y11     la211 eta2=~y12     la221 eta3=~y13     la231 eta4=~y14
##     1.000     1.203     1.000     1.195     1.000     1.204     1.000
##     la241     y11~1     la210     y12~1     la220     y13~1     la230
##     1.080     0.000     0.313     0.000     0.380     0.000     0.307
##     y14~1     la240    eta1~1      ga20    eta3~1      ga40     eps11
##     0.000     0.382     0.000     0.398     0.000     0.234     0.941
##     eps21     eps12     eps22     eps13     eps23     eps14     eps24
##     1.020     1.136     0.857     0.915     1.038     0.901     1.158
##      psi1      psi2      psi3      psi4 xi1=~eta1      ga21 xi2=~eta3
##     0.955     1.141     1.390     0.681     1.000     0.649     1.000
```

```
##      ga41   varxi1   varxi2     mxi1     mxi2  xi1~~xi2  vareta1
##     0.858    2.694    2.580    0.450    0.928     1.721    3.649
##   vareta2  vareta3  vareta4   vary11   vary21    vary12   vary22
##     2.277    3.970    2.583    4.590    6.303     3.413    4.106
##    vary13   vary23   vary14   vary24   rely11    rely21   rely12
##     4.885    6.795    3.484    4.173    0.795     0.838    0.667
##    rely22   rely13   rely23   rely14   rely24    spey11   spey21
##     0.791    0.813    0.847    0.741    0.722     0.208    0.219
##    spey12   spey22   spey13   spey23   spey14    spey24   cony11
##     0.334    0.397    0.284    0.297    0.196     0.191    0.587
##    cony21   cony12   cony22   cony13   cony23    cony14   cony24
##     0.619    0.333    0.395    0.528    0.551     0.546    0.532
```

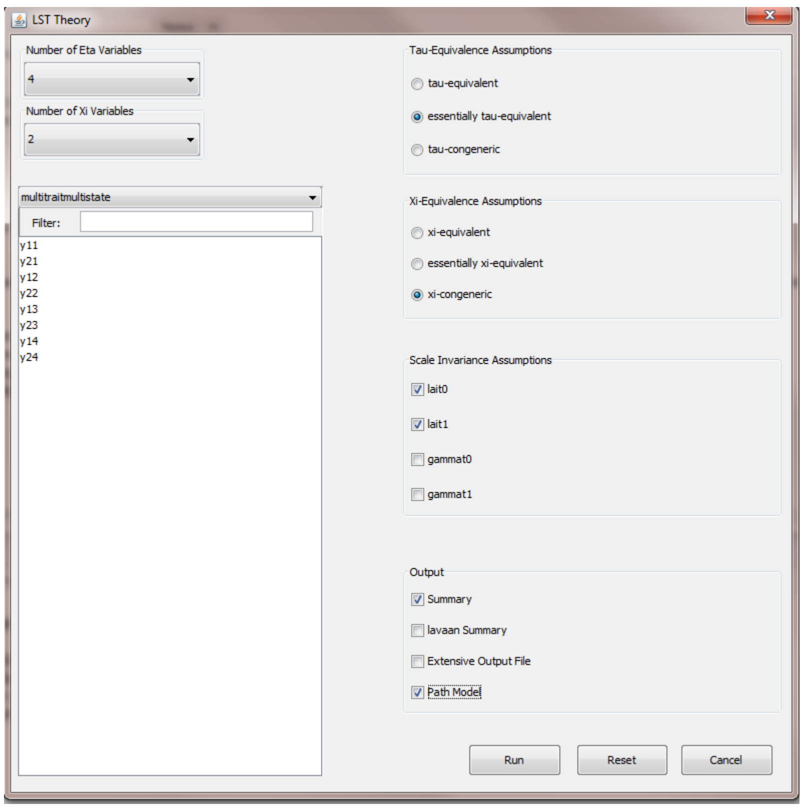
6 Plot LST-R Theory Models with `semPlot`



7 Graphical User Interface `lsttheoryGUI`

The graphical user interface is under development. It currently contains two menu items: One for loading the datasets included in the package and one for specifying the LST-R theory model. Figure 7 shows a screenshot of the dialog that can be used to load datasets.

Figure 7 shows a screenshot of the dialog for specifying the LST-R theory models. The dialog is a convenient graphical interface for the `lsttheory` function described previously. The graphical user interface provides easy access to almost all functionality described earlier in this vignette.


LST Theory
Number of Eta Variables
4
Number of Xi Variables
2
multitraitmultistate
Filter:
y11
y21
y12
y22
y13
y23
y14
y24
Tau-Equivalence Assumptions
tau-equivalent
essentially tau-equivalent
tau-congeneric
Xi-Equivalence Assumptions
xi-equivalent
essentially xi-equivalent
xi-congeneric
Scale Invariance Assumptions
lait0
lait1
gammat0
gammat1
Output
Summary
lavaan Summary
Extensive Output File
Path Model
Run
Reset
Cancel