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lavaanExtra: Convenience Functions for Package *lavaan*

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Summary

{lavaanExtra} is an R package that offers an alternative, vector-based syntax to package {lavaan}, as well as other convenience functions such as naming paths and defining indirect links automatically. It also offers convenience formatting optimized for a publication and script sharing workflow.

Statement of need

{lavaan} (Rosseel, 2012) is a very popular R package for structural equation modeling (SEM). {lavaan} requires familiarizing oneself with a specific syntax to define latent variables, regressions, covariances, indirect effects, and so on.

{lavaanExtra} does mainly two things. First, it offers an alternative, code-efficient syntax. Second, it facilitates the analysis-to-publication workflow by providing publication-ready tables and figures.

Alternative Syntax

There is a single function at the center of the proposed alternative syntax, `write_lavaan()`. The idea behind `write_lavaan()` is to define individual components (regressions, covariances, latent variables, etc.), provide them to the function, and have it write the lavaan model for you, so you don't have to worry about making typos in the specific symbols required for each aspect of the model.

There are several benefits to this approach. Some lavaan models can become very large. By defining the entire model every time, not only do we break the DRY (Don't Repeat Yourself) principle, but our scripts can become long and unwieldy. This problem gets worse in the scenario where we want to compare several variations of the same general model. `write_lavaan()` allows you to reuse your code components, say, your latent variables only, for future models.

This aspect also allows better control over your code. If you made a mistake in your five SEM models definition, you will have to change it at all five places within your script. With `write_lavaan()`, you only need to change it once, at the relevant location, and it will of course update future occurences automatically.

The vector-based approach also allows the use of functions to define components. For example, if all scale items are named consistently, say x1 to x50, one can use `paste0("x", 1:50)` instead of typing all the items by hand and risk making mistakes.

Another issue with lavaan models is readability of the code defining the model. One can go in lengths to make it pretty, but not everyone goes to this extra mile, and the model formatting is certaintly not standardized. With `write_lavaan()`, not only is the model standardized, but it is also neatly divided in clear and useful categories.

Finally, for beginners, it can be difficult to remember the correct lavaan symbols for each specific operation. `write_lavaan()` uses intuitive names to convert the information to the correct symbols, meaning you don't have to rely on memory as much. Even for people familiar with lavaan syntax, this approach can save time. The function also saves time by defining the named paths automatically, with clear and intuitive names.

I provide a simple CFA example below, where the latent variables visual, textual, and speed are defined by items 1 to 9:

```
library(lavaanExtra)

latent <- list(visual = paste0("x", 1:3),
               textual = paste0("x", 4:6),
               speed = paste0("x", 7:9))

model.cfa <- write_lavaan(latent = latent)
cat(model.cfa)
```

```
## ##################################################
## # [-----Latent variables (measurement model)-----]
##
## visual =~ x1 + x2 + x3
## textual =~ x4 + x5 + x6
## speed =~ x7 + x8 + x9
```

Should we want to use these latent variables in a full SEM model, we do not need to define the latent variables again, only the new components. In the example below, the dependent variables DV (`speed` and `textual`) are mediated by the mediator M (`visual`) and predicted by the independent variables IV (`ageyr` and `grade`). Similarly, we specify covariances between the DVs and IVs, and in this case our indirect effects can be determined automatically.

```
DV <- c("speed", "textual")
M <- "visual"
IV <- c("ageyr", "grade")

mediation <- list(speed = M, textual = M, visual = IV)
regression <- list(speed = IV, textual = IV)
covariance <- list(speed = "textual", ageyr = "grade")
indirect <- list(IV = IV, M = M, DV = DV)

model.sem <- write_lavaan(mediation, regression, covariance,
                          indirect, latent, label = TRUE)
cat(model.sem)
```

```
## ##################################################
## # [-----Latent variables (measurement model)-----]
##
## visual =~ x1 + x2 + x3
## textual =~ x4 + x5 + x6
## speed =~ x7 + x8 + x9
##
## ##################################################
## # [-----------Mediations (named paths)-----------]
##
## speed ~ visual_speed*visual
## textual ~ visual_textual*visual
```

```
## visual ~ ageyr_visual*ageyr + grade_visual*grade
##
## ################################################
## # [---------Regressions (Direct effects)---------]
##
## speed ~ ageyr + grade
## textual ~ ageyr + grade
##
## ################################################
## # [------------------Covariances-----------------]
##
## speed ~~ textual
## ageyr ~~ grade
##
## ################################################
## # [--------Mediations (indirect effects)---------]
##
## ageyr_visual_speed := ageyr_visual * visual_speed
## ageyr_visual_textual := ageyr_visual * visual_textual
## grade_visual_speed := grade_visual * visual_speed
## grade_visual_textual := grade_visual * visual_textual
```

Tables

The most popular {lavaanExtra} function for tables is `nice_fit()`, which extracts only some of the most popular fit indices, compares them among models automatically, and formats the output as an APA-style flextable (Gohel & Skintzos, 2023), through the {rempsyc} package (Thériault, 2022). Below we fit our two earlier models and feed them to `nice_fit()` as a named list:

```
library(lavaan)
fit.cfa <- cfa(model.cfa, data = HolzingerSwineford1939)
fit.sem <- sem(model.sem, data = HolzingerSwineford1939)

fit_table <- nice_fit(dplyr::lst(fit.cfa, fit.sem), nice_table = TRUE)
```

```
fit_table
```

Model	χ^2	*df*	χ^2/df	*p*	CFI	TLI	RMSEA	SRMR	AIC	BIC
fit.cfa	85.31	24	3.55	< .001***	0.93	0.90	0.09	0.06	7,517.49	7,595.34
fit.sem	116.26	36	3.23	< .001***	0.93	0.89	0.09	0.06	8,638.13	8,749.25
Ideal Value[a]	—	—	**< 2 or 3**	**> .05**	**≥ .95**	**≥ .95**	**< .06-.08**	**≤ .08**	**Smaller is better**	**Smaller is better**

[a]As proposed by Schreiber et al. (2006).

The table can then be saved to word simply using `flextable::save_as_docx()` on the resulting `flextable` object.

```
flextable::save_as_docx(fit_table, path = "fit_table.docx")
```

It is similarly possible to prepare APA tables in Word with the regression coefficients

(`lavaan_reg()`), covariances (`lavaan_cov()`), or indirect effects (`lavaan_ind()`). For example, for indirect effects:

```
lavaan_ind(fit.sem, nice_table = TRUE)
```

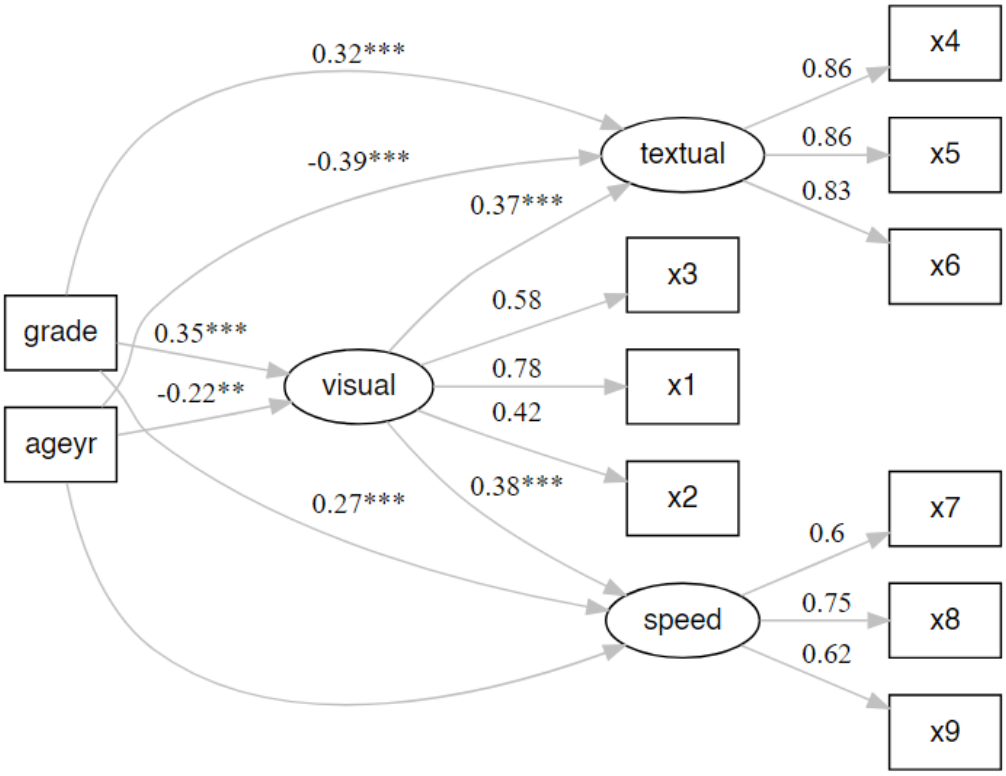
Indirect Effect	Paths	β	*p*
ageyr → visual → speed	ageyr_visual*visual_speed	-0.08	.020
ageyr → visual → textual	ageyr_visual*visual_textual	-0.08	.015
grade → visual → speed	grade_visual*visual_speed	0.13	.002
grade → visual → textual	grade_visual*visual_textual	0.13	.001

Figures

There are several packages designed to plot SEM models, but few that people consider satisfying or sufficiently good for publication. There are two packages that stand out, however, {lavaanPlot} (Lishinski, 2021) and {tidySEM} (van Lissa, 2023). However, even for those excellent packages, most people do not view them as publication-ready or at least optimized in the best possible way.

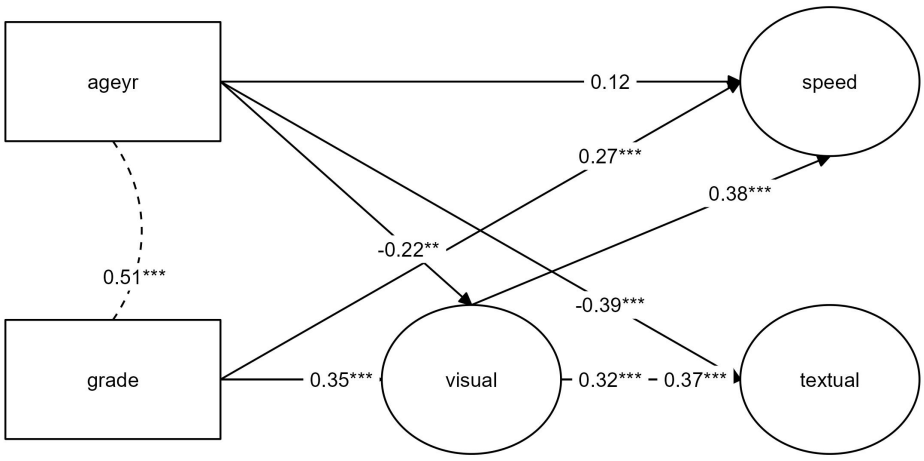
This is what `nice_lavaanPlot` and `nice_tidySEM` aim to correct. `nice_lavaanPlot` is not optimal for publications but will yield excellent results for a quick and easy check.

```
nice_lavaanPlot(fit.sem)
```



The best option for publication is `nice_tidySEM`. When our model is simply made of three "levels": independent variables, mediators, and dependent variables, we can specify the layout by simply feeding it the object `indirect` that we created earlier.

```
nice_tidySEM(fit.sem, layout = indirect, label_location = 0.75)
```



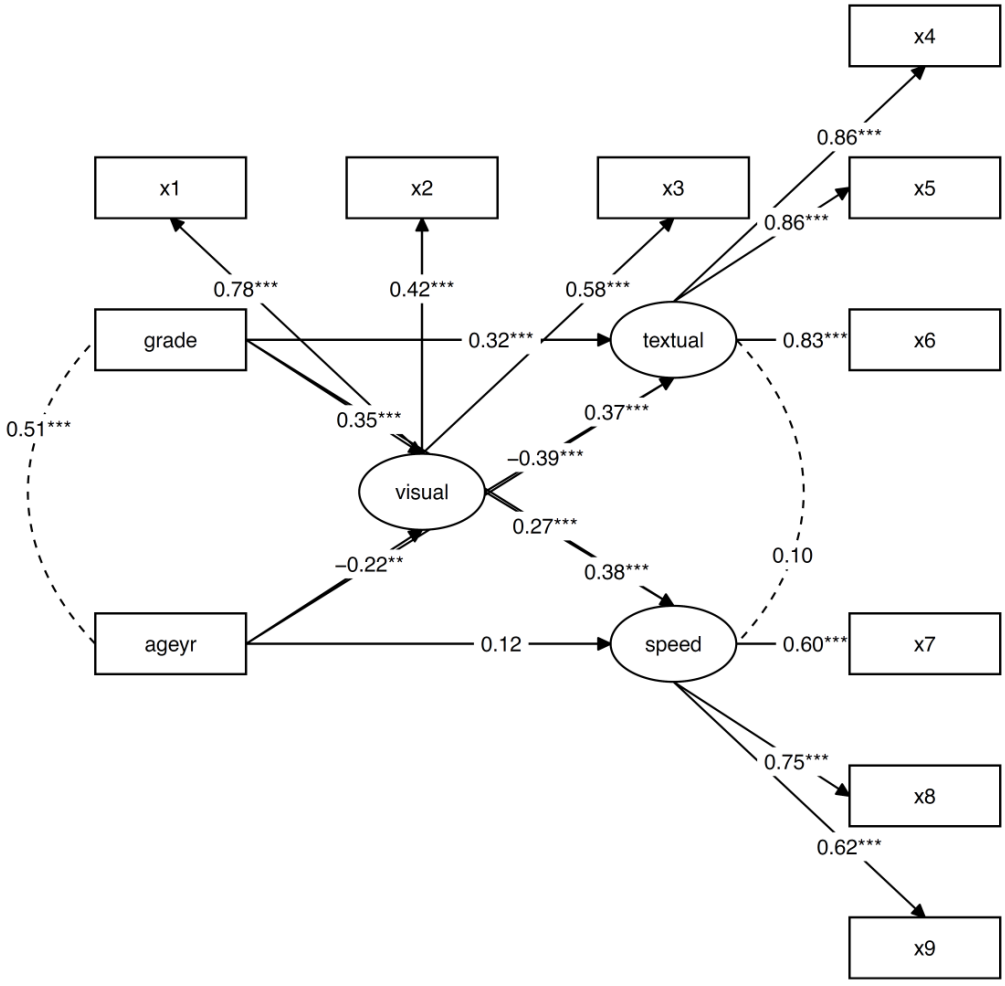
However, when the model is more complex (such as when including items), it is necessary to specify the layout manually using a matrix or data frame.

```
mylayout <- data.frame(
  IV = c("", "x1", "grade", "", "ageyr", "", ""),
  M = c("", "x2", "", "visual", "", "", ""),
  DV = c("", "x3", "textual", "", "speed", "", ""),
  DV.items = c(paste0("x", 4:6), "", paste0("x", 7:9)))
```

```
as.matrix(mylayout)
```

```
##       IV       M         DV         DV.items
## [1,] ""       ""        ""         "x4"
## [2,] "x1"     "x2"      "x3"       "x5"
## [3,] "grade"  ""        "textual"  "x6"
## [4,] ""       "visual"  ""         ""
## [5,] "ageyr"  ""        "speed"    "x7"
## [6,] ""       ""        ""         "x8"
## [7,] ""       ""        ""         "x9"
```

```
nice_tidySEM(fit.sem, layout = mylayout)
```



This figure can be saved using `ggplot2::ggsave()` (Wickham, 2016).

```
ggplot2::ggsave("my_semPlot.pdf", width = 7, height = 4)
```

Availability

The {lavaanExtra} package is licensed under the MIT License. It is available on CRAN, and can be installed using `install.packages("lavaanExtra")`. The full tutorial website can be accessed at: https://lavaanExtra.remi-theriault.com/. All code is open-source and hosted on GitHub, and bugs can be reported at https://github.com/rempsyc/

lavaanExtra/issues/.

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