

Ω nyx User Guide



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Chapter 1

Introduction

Ω nyx is a free software environment for creating and estimating Structural Equation Models (SEM). It provides a graphical user interface that facilitates an intuitive creation of models. Ω nyx provides a powerful backend for performing maximum likelihood estimation of parameters in models. Furthermore, Ω nyx provides import from and export to OpenMx, a free SEM package for the statistical computing language R. Also, publication-quality figures can be exported in a vector representation to L^AT_EX or in a bitmap representation to JPEG.

Structural Equation Modeling is a frequently used multivariate analysis technique in the behavioral and social sciences. SEM are linear models of both observed and latent variables and their relationships. The maximum-likelihood-framework allows estimation of structural parameters even on the latent level by modelling the covariances and expectations of the observed variables.

There are various text books that cover the essentials of SEM, for example, Bollen(1989). SEM can be conceived of as a unification of several multivariate analysis techniques under a single framework. Particularly, linear regression, ANOVA, correlation, path analysis, factor analysis, autoregression, and growth curve modeling can be considered special cases of SEM.

Ω nyx is intended to be a teaching tool for SEM. It facilitates a graphical approach to modeling that offers an interface to OpenMx and Mplus code. That is, SE modeling can be taught in a graphical approach without the need to teach a specific modeling language. In the progress of a course, a transition from the purely graphical approach to a specific modeling language can be made. Ω nyx offers an export of models to the free OpenMx language and to the commercial Mplus language. An interactive code view allows users to track and compare changes to the model specification in the selected language that are elicited by changes to the graphical representation.

The backend of Ω nyx allows to estimate parameters with Maximum Likelihood or Least Squares. The possible space of solutions is systematically searched with multiple start values, which allows to find and weight different possible solution, or different local minima of similar fit value. This document provides a brief introduction to the features of Ω nyx . The creation of models and the basic mechanisms of the underlying estimation engine are explained. More details regarding Ω nyx can be found on the website <http://onyx.brandmaier.de>.

Chapter 2

Creating Models

2.1 Model Panels

In *Onyx*, a model is created in a Model Panel (Figure 2.1). Double click on the *Onyx* workspace, and a new model panel is created. An alternate way to create a new model panel is to click **File | Create empty model** on the top menu bar. Right click (or **SHIFT + click** for mac) on the top left corner to rename the model panel. An asterisk after the model name shows that the current model has changed, but has not been saved.

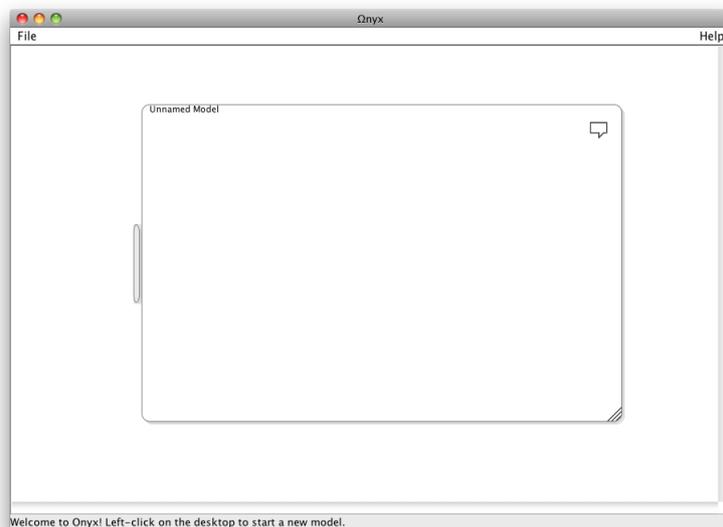


Figure 2.1: Model Panel

To rearrange the location of the model panel, you can click on one of the border, and drag the model panel. To resize the model panel, left click and drag the anchor on the bottom right corner.

If you want to create a second model, you need to create a new model panel. That is, each model needs to be created on a separate model panel. However, you can have more than one model panels at a time. In order to maximize the working space, Ω nyx has incorporated a function to *iconify* a model panel. Double click on the border of a model panel to *iconify* (Figure 2.2); double click again to restore the model panel. The iconified model panels can also be relocated by dragging them on the Ω nyx working space.

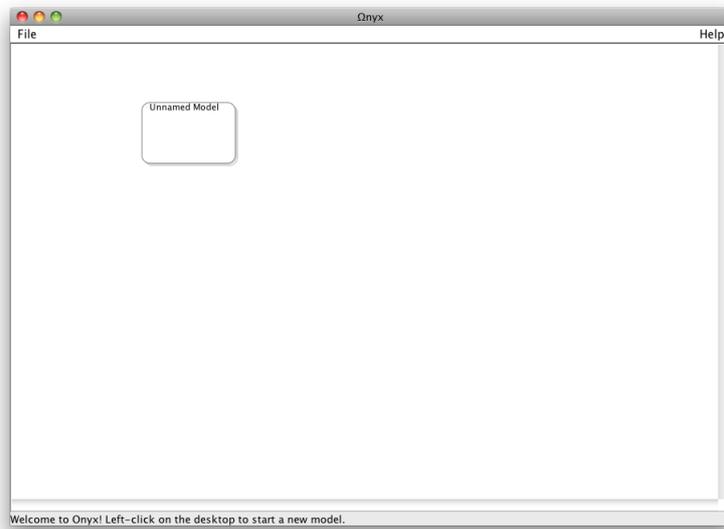


Figure 2.2: Iconified model panel

To remove a model panel from the Ω nyx workspace, right click on the model panel and click **Close Model**. If you have not saved the working model, a dialog window will pop up asking you to save the model (see Section 2.5).

2.2 Variables

To create a latent variable, double click on the model panel; a latent variable is represented by a circle node. To create a manifest variable, press **SHIFT** + double click on the model panel; a manifest variable is represented by a

square node. By default, a double-headed arrow directing towards itself is created with each variable, denoting the error term.

To change the default variable from a latent variable to a manifest variable, right click on the model panel, and click **New Nodes: Manifests**. Now, a manifest variable will be created with a double click, whereas a latent variable will be created with a **SHIFT + double click**. An alternative option of swapping latent/manifest variable is to right click on the latent/manifest variable, and click **Swap Latent / Manifest** (Figure 2.3).

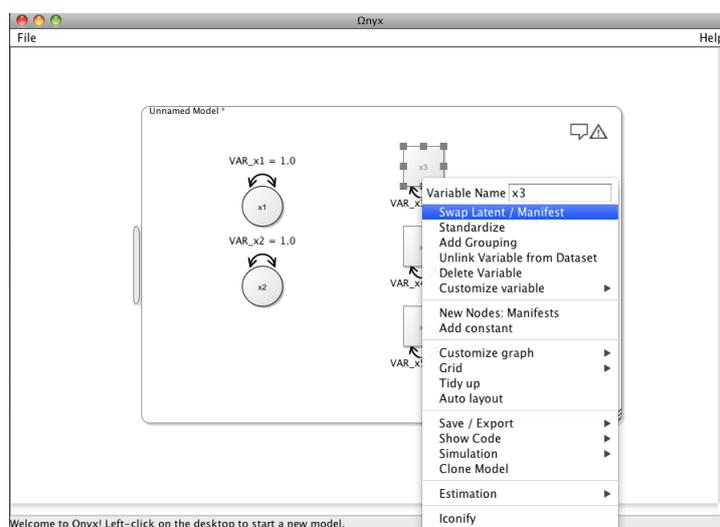


Figure 2.3: Create variables

For manifest variables that are not normalized, you will need to add a constant mean to the model. To create a constant means, right click on the model panel, click **Add constant**; a constant means triangle will be created (Figure 2.4). For more complicated models, you can have more than one constant means in the model to avoid crossing paths.

Onyx also offers a convenient option to create models with standardized variables. Right click on a manifest variable and select **Standardize**. The selected manifest variable is now shown with an inner border (Figure 2.5), indicating that the variable is standardized. You can double check the descriptive statistics of the standardized variable (mean = 0.00; variance = 1.00).

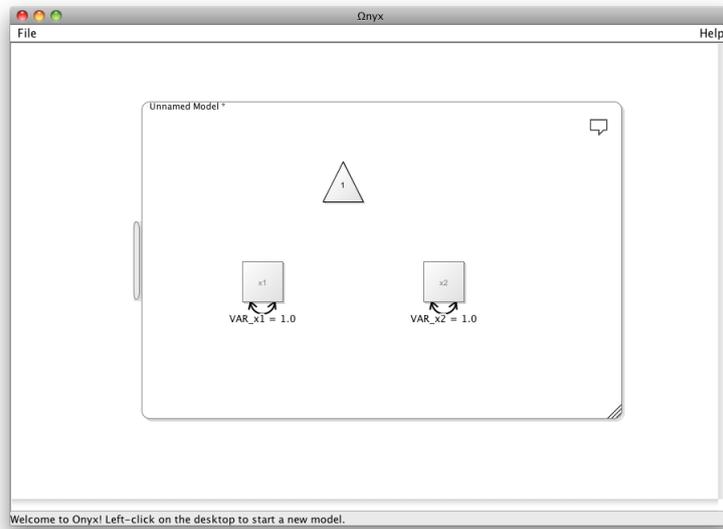


Figure 2.4: Constant means triangle

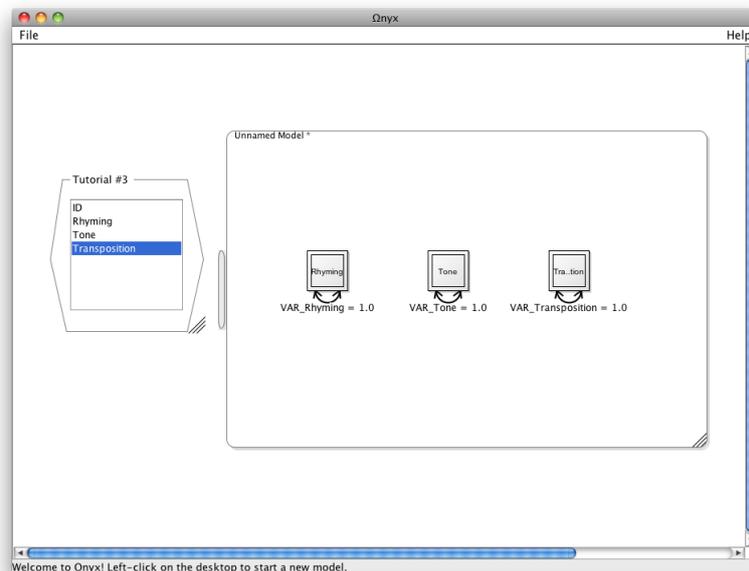


Figure 2.5: Standardized manifest variables

2.3 Paths

Regression relationships between variables are represented by one-headed arrows (\rightarrow), whereas covariance relationships are represented by double-headed arrows (\leftrightarrow). Right click on a variable and drag onto another variable; a one-headed arrow will be created based on the direction of the mouse drag. To change the direction of the arrow, right click on the path, and click **Toggle path heads**. Repeat the procedure, and the one-headed arrow will be modified into a double-headed arrow.

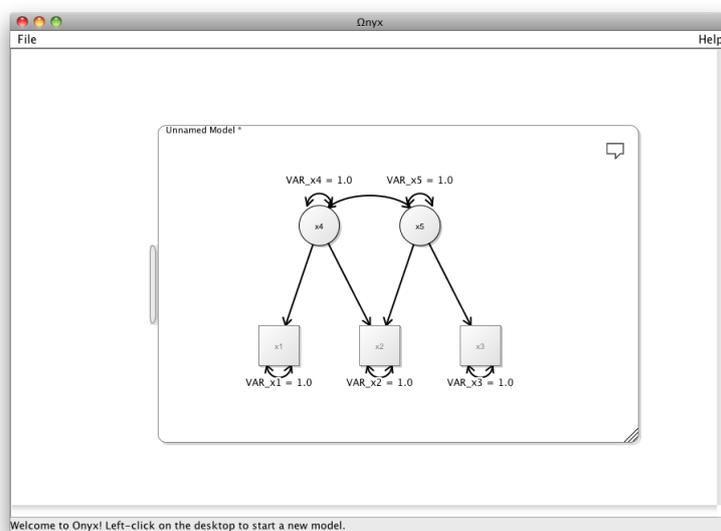


Figure 2.6: Create paths

A more efficient method to create a double-headed arrow is to press **SHIFT** as you right click on a variable and drag onto another variable (Figure 2.6).

To rename the paths, right click on a path, and type the name of the path in the text box labeled: **Path name** (see Section 2.7).

2.4 Edit

Onyx offers the ease of editing models with simple mouse clicks and/or keyboard shortcuts.

Clone The cloning function enables users to make copies of existing models, rather than creating every model from scratch. To do so, right click on the

model panel, and click **Clone Model**. A new model panel with the *cloned* model will be created.

Copy & Paste Use the keyboard shortcut CTRL + C to copy and CTRL + V to paste. The copy & paste function extends to variables in Ω_{nyx} . If only one variable is selected, the copy & paste function will make a copy of the variable and paste it on the active model panel. If two or more connected variables are selected, the copy & paste function will make a copy of the existing path connections as well. Copied variables will be denoted with a prime (represented as the ' symbol) after the variables' names. For example, variable X will be copied as variable X'.

Delete Right click on a variable/path, click **Delete Variable/Delete Path** to delete. You can also select multiple variables, then press DELETE for multiple deletion. To remove a path, right click on a path and select **Delete path**.

Undo Use the keyboard shortcut CTRL/CMD + Z to reverse the most recent editing command. By default, the last 5 edits is retained; older edits cannot be undone.

Select Left click on a variable to select one variable. SHIFT + left click on two or more variables to select multiple variables. You can also draw a selection box (left click + drag) on the model panel to select multiple variables.

2.5 Save/Export

To save a model, right click on the model panel and click **Save / Export** (Figure 2.7), or press CTRL/CMD + S. Indicate where you would like to save the model, and click **Save**. By default, the model will be saved as an *.onyxml file, which can be opened with Ω_{nyx} .

To load a previously saved model, click **File | Load Model**. The model will be loaded onto a new model panel.

To save a model diagram into another format (e.g., JPEG, LaTeX), right click on the model panel and click **Export JPEG/LaTeX**. To export a model into corresponding codes for OpenMx or MPlus, click **Export model to OpenMx/Mplus** (see also Section 2.9).

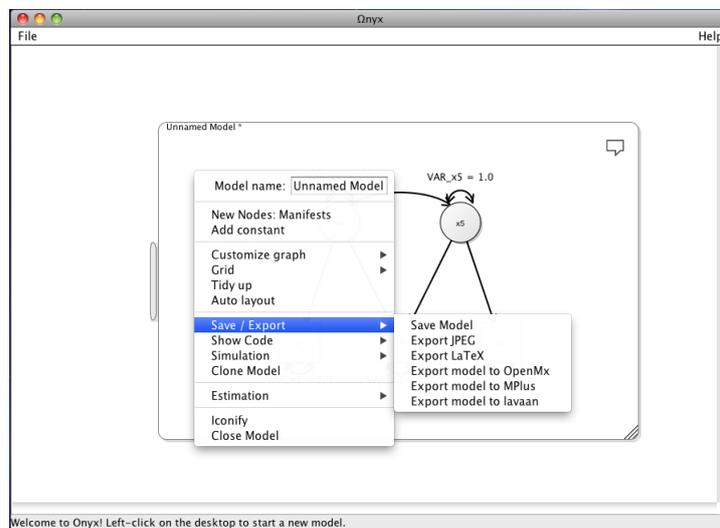


Figure 2.7: Save a model

2.6 Data Panels

Before *Onyx* can start the estimation process, the model needs to be connected to a dataset. To load an existing dataset, click **File** | **Load data** on the top menu bar. You can also right click on the workspace, click **Load Data**. If you do not have an existing dataset, you can click **File** | **Load tutorial data** to load a tutorial dataset. Note that data files should be tab-separated (*.dat), or comma-separated (*.csv) files, with the first row containing the variable names.

In *Onyx*, a dataset is represented in a hexagonal-shaped Data Panel (Figure 2.8). Each column (variable) in a dataset is represented as a list of variables in the data panel. Similar to a model panel (see Section 2.1), a data panel can be *iconified*. Double click on the border of a data panel to *iconify*; double click again to restore the data panel. Hover the mouse over a variable, and the descriptive statistics (e.g., mean, standard deviation, minimum, maximum) of the particular variable will be shown on a pop-up menu.

Left click on a variable on the data panel, and drag it onto the model panel; the variable will be represented as a manifest variable. You can also select multiple variables on the data panel, and drag them onto the model panel. Move the mouse onto a manifest variable (e.g., **Rhyming**), and the corresponding variable is highlighted on the data panel.

Note that you can create models without having a Data Panel; *Onyx*

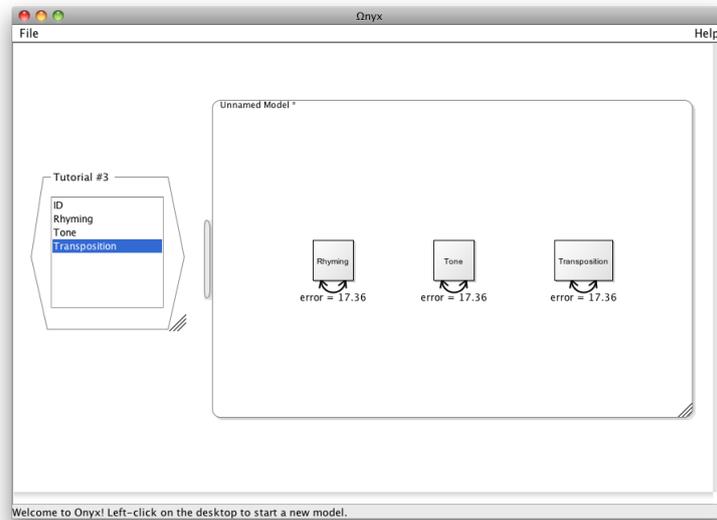


Figure 2.8: Data panel with corresponding model

offers several options to connect models with datasets.

- i. Create a model in the model panel. As the manifest variables are not connected to a dataset, they are shown in a lighter shade of grey (Figure 2.9). Load the dataset of your choice, then drag the variables from the data panel onto the manifest variables in the model panel. Manifest variables connected to the dataset will now be shown in black. The names of the manifest variables will change to reflect the names of the corresponding variables in the dataset (Figure 2.10).
- ii. Create a model in the model panel, with the names of the manifest variables matching those in your dataset. As the manifest variables are not connected to a dataset, they will be shown in a lighter shade of grey. Load the dataset of your choice, right click on the data panel, and click **Send data to model** (Figure 2.11). Data in the data panel will be sent to the manifest variables with matching names. Manifest variables connected to the dataset will now be shown in black.
- iii. For cases in which no prior dataset is available, data simulation is possible with Ω nyx . Create your model in the model panel, then right click on the model panel, select **Simulation**. Enter the number of cases in the **Data rows** desired, and click **Start Simulation** (Figure 2.12). A **Simulated Dataset** will be generated in a new data panel, with manifest

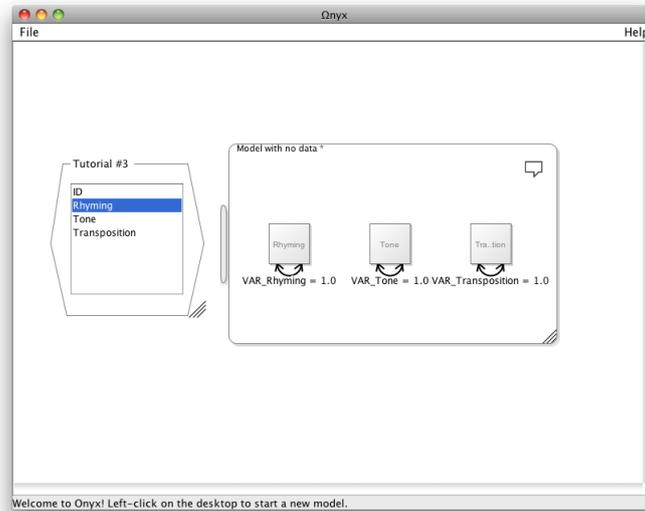


Figure 2.9: Model with no connected data

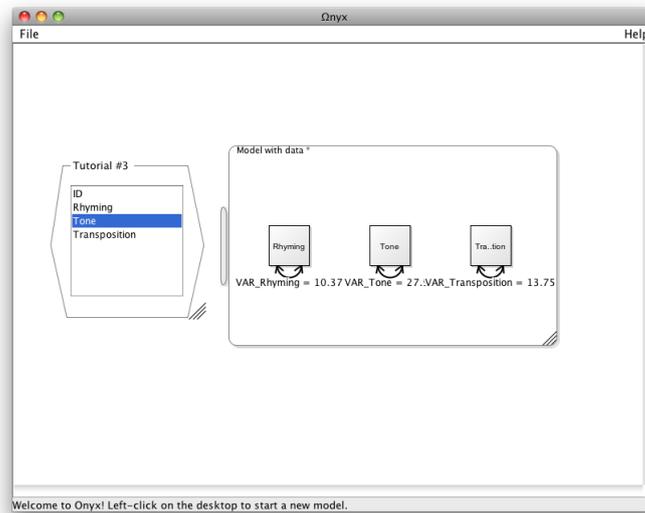


Figure 2.10: Model with connected data

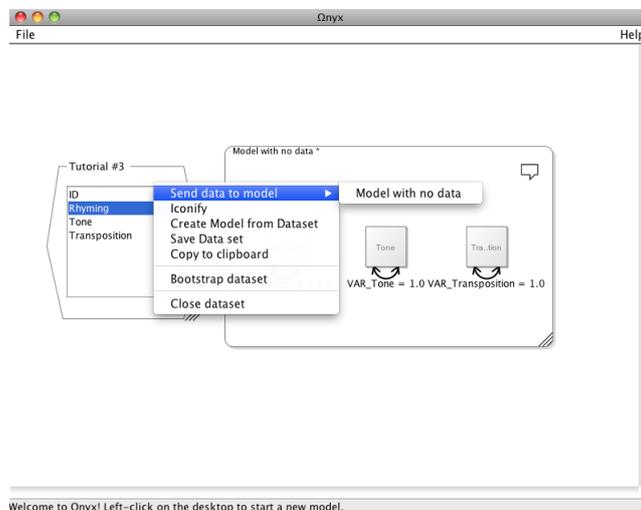


Figure 2.11: Send data to model

variables matching those in the model panel. Next, send the simulated to the model, and parameters will be estimated. To save the simulated dataset, right click on the data panel and click **Save Dataset**. You can also choose to **Bootstrap dataset** and/or **Resimulate dataset** (Figure 2.13). Note that the new simulated dataset will replace the prior one; it is suggested to save the simulated data before proceeding with resimulation.

2.7 Parameters

Parameters in Onyx are named according to their properties. $\xrightarrow{x1_TO_x2}$ represents a regression weight from variable $x1$ to variable $x2$. $\xleftrightarrow{VAR_x1}$ represents the error term of variable $x1$. $\xleftrightarrow{COV_x1_x2}$ represents the covariance between variable $x1$ and variable $x2$. The default setting of Onyx distinguishes between free and fixed parameters; parameter names and values are shown for freely estimated parameters, whereas only parameter values are shown for fixed parameters. To customize this setting, see Section 3.3 for details.

By default, the value of a path is fixed to **Path value = 1**. You can change the fixed parameter value in the text edit field labelled **Path value**. To freely estimate a parameter, right click on a path, and click **Free parameter**. The parameter name and the estimated value will be shown on the model. You can right click on a path and rename the parameter in the text edit

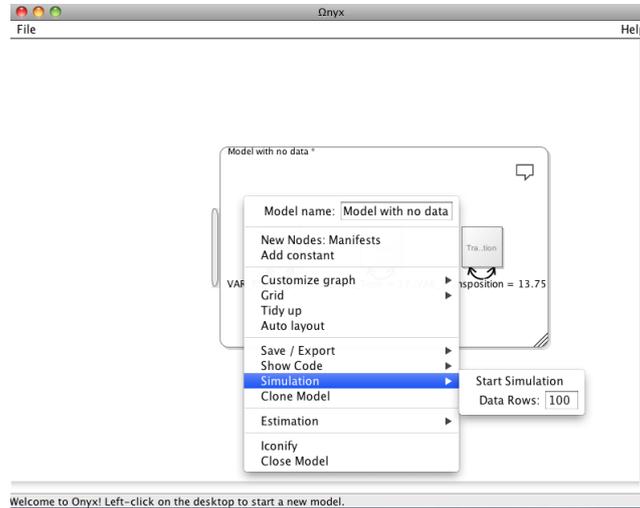


Figure 2.12: Simulate Data

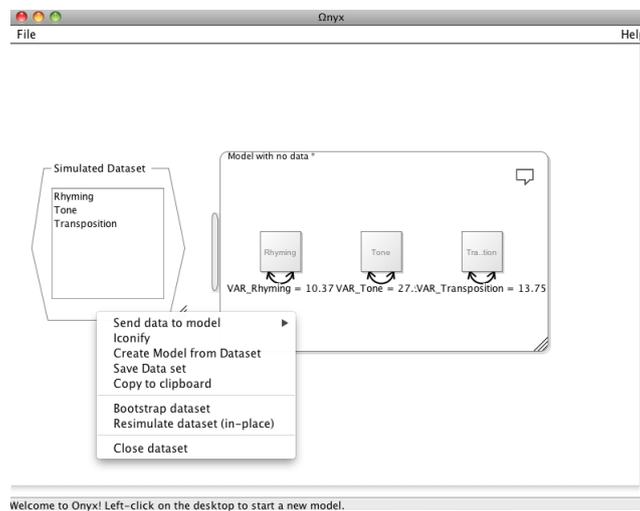


Figure 2.13: Resimulate Data

field labelled **Path name**. Onyx supports Greek letters and pseudo latex (see Section 3.3) input for variable/path names.

To constrain the estimated parameters to be equal across several variables and/or paths (e.g., same measurement error across manifest variables), you can apply the same parameter names across the constrained variable/path names (Figure 2.14). Paths with the same names will be fixed to be the same.

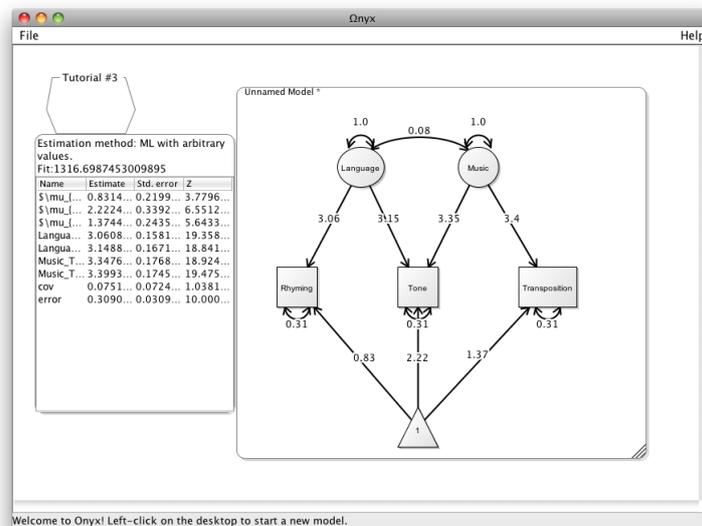


Figure 2.14: demo03.model with constrained error terms

As the model is being created and revised, estimated parameter values are automatically shown on the model panel. Changes to the model are reflected by simultaneous changes (if any) to the parameter estimations. You can also view all the estimates in a text format. Double click the results handle on the left of the model panel to open the Results Drawer. Right click on the results drawer, click **Export as Text** or **Export as HTML** to export the results as a text (*.txt) or HTML (*.html) file. Double click the results drawer again to close.

You can also view the summary of the estimated parameters. Right click on the model panel, select **Estimation | Show estimate summary**. The estimate summary will be shown in a separate panel (Figure ??). To save the results into a text file (*.txt), right click on the estimate summary, select **Save code**. Right click on the estimate summary, and select **Close view** to close the estimate summary.

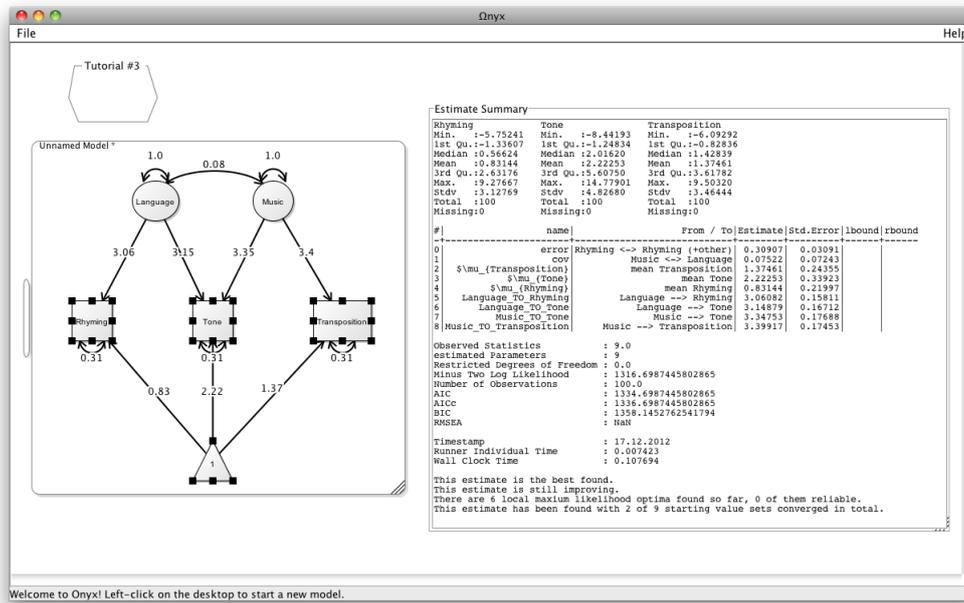


Figure 2.15: Model with estimate summary

Moreover, *Onyx* offers the option of exporting codes into commonly used SEM software (e.g., *OpenMx*, *Mplus*) for data analyses (see also Section 2.9). Right click on the estimate summary, select **Type of Export**, and you can select to export the code into *OpenMx*, *Mplus*, RAM notation, or *Onyx Java*. For example, click to export as *OpenMx*. As shown in Figure 2.17, the model specification is automatically generated as *OpenMx* codes. To save the codes into a text file (*.txt), right click on the *OpenMx* codes, and select **Save code**.

2.8 Estimation

Onyx estimates parameters in models using a maximum likelihood approach. Given an initial guess of the parameters, the so-called *starting values*, the solution is found by iteratively improving the temporary solution until the likelihood is maximal. This principle approach is common to all SEM programs. To search a larger portion of the parameter space for potentially better solutions, *Onyx* starts several estimation processes for each model. These processes are based on various approaches to obtain starting values, among these are:

1. Least-squares estimate as starting values
2. Random starting values
3. Default starting values for paths, covariances, and variances

Estimates based on the user's starting values are shown as the results on the model panel (and the results drawer). However, *better* estimates may be found through iterations of estimation processes. A sparkling symbol (✦) on the top right corner of the model panel indicates that new estimates have been found. To view all available estimated values, right click on the model panel, click **Estimation | Select estimate** (Figure 2.16). *Ωnyx* provides a list of all the estimated values; click on one and the estimated values will be reflected on the model panel. You can also select to show the starting values, or the best Maximum Likelihood or Least Squares estimates.

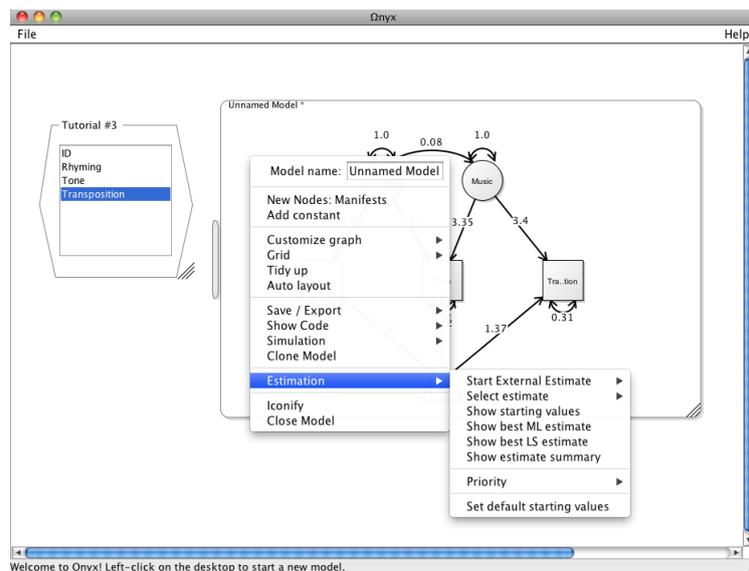


Figure 2.16: Select estimates

2.9 Code View

In addition to the graphical user interface, *Ωnyx* provides a code view for users. Right click on the model panel and click **Show Code**, or press CTRL/CMD + K, then select **Onyx Java**. You can also select to view the **Correlation Matrix** as you make changes to the model.

Onyx offers the option of exporting codes into commonly used SEM software (e.g., OpenMx, Mplus) for data analyses. Model specification codes are automatically generated as a model is being created and revised. To view the codes generated, right click on the model panel and click **Show Code**, or press CTRL/CMD + K to open the code panel (Figure 2.17). You can select to view the codes generated for OpenMx, Mplus, and/or RAM matrices.

Similar to the estimated parameters, changes to the corresponding model are reflected in the code panel. The most recent additions to the model are highlighted in yellow. To close the code panel, right click on the code panel, and click **Close view**. To save the codes into a text file (*.txt), right click on the code panel, and select **Save code**.

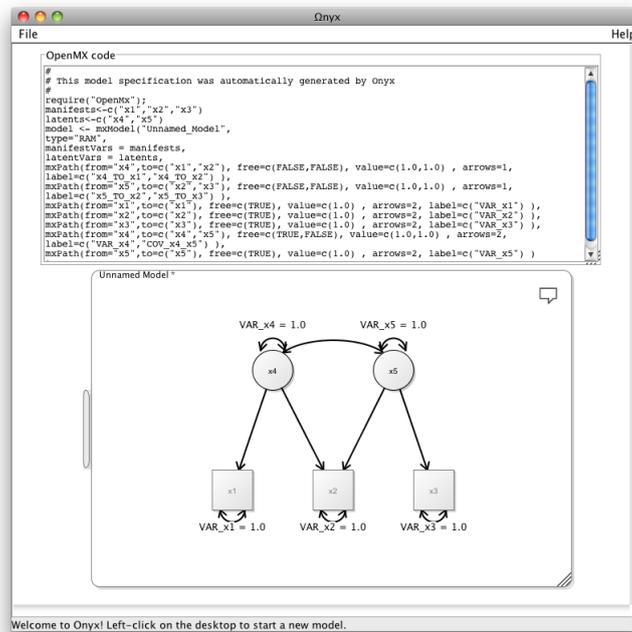


Figure 2.17: Model panel with corresponding R codes

2.10 Priority settings

When estimating larger models and/or multiple models simultaneously, it can make sense to prioritize the estimation process of specific models. Right click on the model panel, click **Estimation | Priority** to customize the priority of the estimation process. In order to free up the memory space of

the computer, you can also choose to pause the estimation process of selected models.

2.11 Model comparison

Onyx uses the likelihood ratio (LR) test to compare two nested models. A model is considered to be nested in another model if restrictions are imposed on one or more parameters of the second model. The LR test compares and tests the difference in log likelihood of the two models.

To conduct a LR test, create two nested models. For example, fix one or more parameters to zero. Double click the model panels to iconify (see Section 2.1). Right click on one model icon and drag it to the other model icon. The dashed line connecting the two model icons indicates a LR comparison (Figure 2.18). Hover the mouse over the black dot, and the results from the LR test will be shown on a pop-up menu. You can also conduct multiple LR tests simultaneously by connecting multiple models.

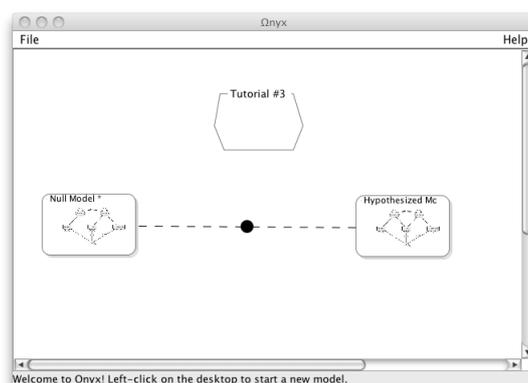


Figure 2.18: Likelihood Ratio test

Chapter 3

Customization

3.1 Layout

Grid Right click on the model panel, click **Toggle display of grid** to show grid; click **Toggle display of grid** again to hide grid (Figure 3.1). Click **Toggle lock to grid** to enable snapping new variables to grid. Grid lock will be applied to all (and new) model panels.

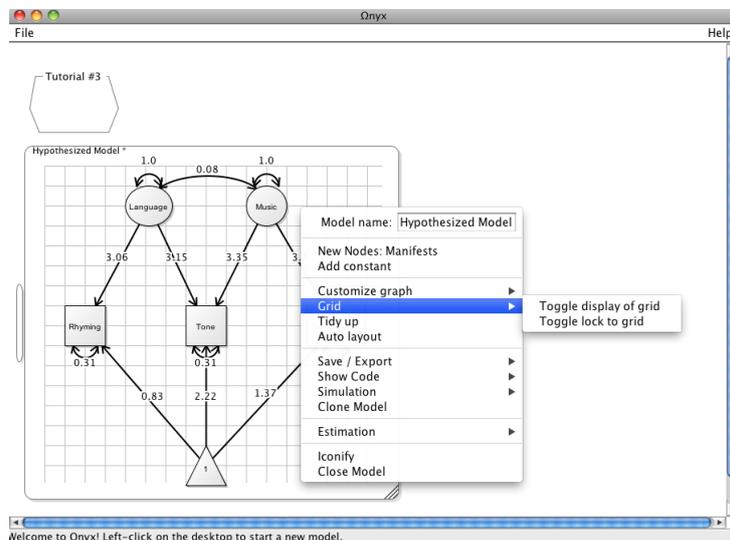


Figure 3.1: Grid display

Auto layout Right click on the model panel, click **Auto layout** to allow automatic layout of the model. The Auto layout function aligns the variables

and maximizes the space on the model panel (Figure 3.2).

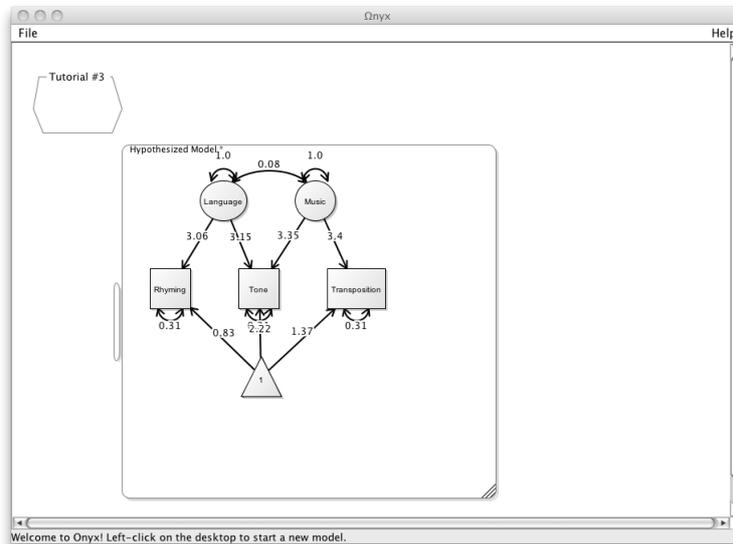


Figure 3.2: Auto layout

Tidy up The Tidy up function provides an alternate option to efficient graph alignment. Right click on the model panel, click **Tidy up**. Variables are aligned to the grid and variables are resized into the same size.

3.2 Formatting

Color To customize the color of variables, right click on the selected variable, click **Customize variable | Change line/fill color**. Color can be selected from the pop-up window (Figure 3.3). Similarly, you can customize the color of paths. Right click on a path, click **Change path color**.

Graph style You can customize the graph styles to suit different purposes (e.g., presentation, publication). The default setting for Onyx is **fancy**, in which variables are shown with gradient shading. Right click on the model panel, select **Customize graph | Style** to change to a different style. Variables in the **Simple** graph style are shown in black and white.

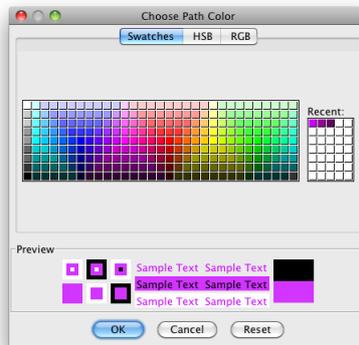


Figure 3.3: Customize color

Line weight Line weight for variables and paths is set to Medium by default. Right click on the model panel, click **Customize graph | Set line weight** to customize the line weight. You can choose among Thin/Medium/Thick line weight.

Path styles Ω nyx offers several path styles for customization (Figure 3.4). Right click on the model panel, click **Customize graph | Select path style**. The selected style will be applied to all paths on the active model panel.

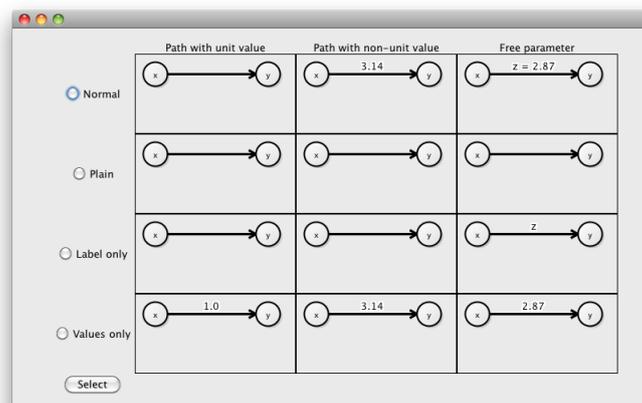


Figure 3.4: Customize path styles

3.3 Mathematical symbols

Greek letters It is possible to display Greek letters as parameter names in Ω nyx. Type the corresponding codes in the text edit field (see Section 2.7).

α	<code>\alpha</code>	η	<code>\eta</code>	ν	<code>\nu</code>	τ	<code>\tau</code>
β	<code>\beta</code>	θ	<code>\theta</code>	ξ	<code>\xi</code>	υ	<code>\upsilon</code>
γ	<code>\gamma</code>	ι	<code>\iota</code>	\omicron	<code>\omicron</code>	ϕ	<code>\phi</code>
δ	<code>\delta</code>	κ	<code>\kappa</code>	π	<code>\pi</code>	χ	<code>\chi</code>
ϵ	<code>\epsilon</code>	λ	<code>\lambda</code>	ρ	<code>\rho</code>	ψ	<code>\psi</code>
ζ	<code>\zeta</code>	μ	<code>\mu</code>	σ	<code>\sigma</code>	ω	<code>\omega</code>

Table 3.1: Greek Letters

Superscripts & subscripts Ω nyx supports some pseudo LaTeX input. Both superscript and subscript commands are preceded by a dollar sign symbol (\$).

The superscript command is

$$\text{\$}\{\text{characters to be superscripted}\}$$

The subscript command is

$$\text{\$}_{\{\text{characters to be subscripted}\}}$$

To use both superscript and subscript in one input, only one preceding dollar sign symbol is needed.

Ω nyx display	Command code
σ^2	<code>\sigma^2</code>
ρ_ω	<code>\rho_{\omega}</code>
$\omega_{\alpha=1}$	<code>\omega_{\alpha=1}</code>
σ_{X1}^2	<code>\sigma^2_{X1}</code>
σ_{latent}^2	<code>\sigma^2_{latent}</code>
$\lambda_1^{(zero)}$	<code>\lambda^{(zero)}_{1}</code>

Table 3.2: Examples for superscript and subscript command

Appendix A

Keyboard Shortcuts

CTRL+F	flip selected variables vertically
CTRL+SHIFT+F	flip selected variables horizontally
CTRL+C	copy selected variables and all paths between them to clipboard
CTRL+V	paste selected variables and all paths between them to clipboard
CTRL+A	select all variables and edges in a graph
CTRL+Z	undo last edit action
CTRL+T	start interactive tutorial
BACKSPACE or DEL	delete currently selected variables and all paths between them
CTRL+G	show/hide grid
CTRL+S	save model
CTRL+NUMBERKEY	selected nodes are grouped together in a node group.
NUMBERKEYS	if mouse is over a path, the path's value is changed accordingly. Otherwise, the respective node group is activated or deactivated.
CTRL+K	open code view (OpenMx code is default)