Ωnyx User Guide

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Chapter 1

Introduction

Ωnyx is a free graphical Structural Equation Modeling (SEM) software for creating and estimating SEMs. It provides a graphical user interface that facilitates an intuitive creation of models, and a powerful backend for performing maximum likelihood estimation of parameters in models. You can use Ωnyx as a stand-alone software or from the statistical computing language R. Ωnyx allows you to import models from OpenMx, a free SEM package for R, and exports scripts to OpenMx, Mplus, lavaan, and sem. Also, publication-quality figures can be exported as vector representation, LaTeXcode, or in bitmap representations.

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 modeling 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.

Ωnyx is intended to be a teaching tool for SEM. It facilitates a graphical approach to modeling that offers an interface to OpenMx, lavaan, sem 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. An interactive code view allows users to track and compare changes to the model specification in the selected scripting language that are elicited by changes to the graphical representation.

The backend of Ωnyx 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 Ωnyx . The creation of models and the basic mechanisms of the underlying estimation engine are explained. More details regarding Ωnyx can be found on the website `http://onyx.brandmaier.de`.

Chapter 2

Installing Ωnyx

System Requirements

- Operating Systems
  - Microsoft Windows 2000/XP/Vista/7/8
  - Mac OS X 10.5 or later
  - Linux (tested on Ubuntu)
- Java Runtime Environment (JRE; version 1.6 or later)

Install Java

If your system does not have Java, or has an older version of JRE (prior to version 1.6), download Java JRE here: `http://java.com/en/download/index.jsp`. To check your current JRE version, type (in the terminal): `java -version`

Java for earlier versions of Mac OS (10.5 or earlier) is supported by Apple; run the Apple updates on your computer to update to the latest version of java. Next, go to `Applications | Java Preferences`; move **java SE 6** to the top.

Run Ωnyx

Download the newest version of Ωnyx from our website: `http://onyx.brandmaier.de`.

The download will be delivered as a `.jar` file. Move this file into the directory of your choice, or you can leave it on your desktop. Double click the `onyx` file with the suffix `.jar` to run Ωnyx .

Quick Start

This tutorial covers basic modeling steps in Ωnyx . We recommend exploring further features in Ωnyx by right-clicking[1] on objects. On a right-click on any object, a context menu containing a list of all operations that can be performed on the respective object, are listed. This includes right-clicks on the desktop, which allows to create a new empty model or load data and models. Ωnyx also comes with an interactive tutorial which you can start from the `help` menu on the right side of the menu bar.

[1] All uses of the right mouse button can alternatively be done with the left mouse button while holding the CTRL key

Chapter 3

Creating Models

3.1 Model Panels

In Ωnyx , a model is contained in a Model Panel (Figure 3.1). Double click on the Ωnyx workspace, and a new model panel is created. An alternative way to create a new model panel is to choose `Create new model` in the `Ωnyx` top menu bar, or by right-click (or CTRL click for MacOS) on the desktop and choosing `Create new model` from the context menu. Right click on the model panel to obtain the context menu with all operations for the model, and a text field for the model name. An asterisk after the model name in the head line of the frame indicates that the current model has unsaved changes.

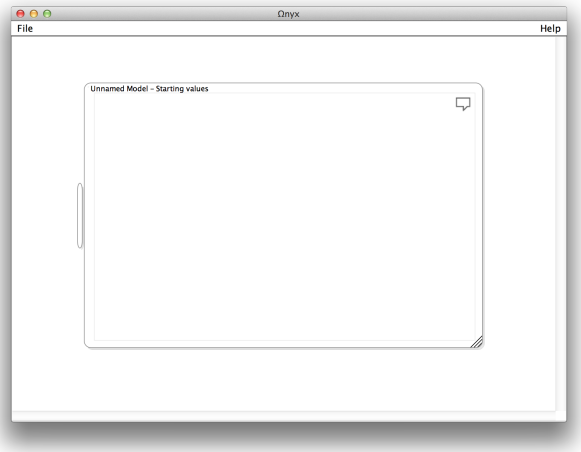

Figure 3.1: Model Panel

To rearrange the location of the model panel, you can click on one of the

border, and drag the model panel around. 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 do so in a new model panel. That is, each model needs to be created on a separate model panel. You can have multiple model panels at a time. In order to maximize the working space, Ωnyx has incorporated a function to *iconify* a model panel. Double click on the border of a model panel to iconify (Figure 3.2), or choose the iconify operation from the context menu; double click again to restore the model panel. The iconified model panels can be relocated by dragging them on the Ωnyx working space.

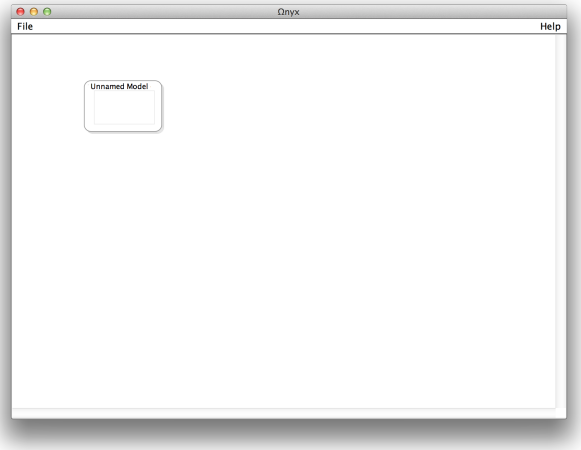

Figure 3.2: Iconified model panel

Choosing `Load Model or Data` from the `Ωnyx` menu or the context menu of the desktop, you can load a previously saved model in Ωnyx . Alternatively, you can drag a file from the file system onto the desktop directly to open a model. In both ways, the model file can be either a Ωnyx save file (stored as `.xml`) or an OpenMx R script; read more about interaction with OpenMx and other sem programs in Section 3.5.

To remove a model panel from the Ωnyx 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 3.5).

3.2 Variables

Choose `Create Variable` from the context menu to create a new variable. This can be either an observed variable, a latent variable, or a constant, represented as circle, square or triangle, respectively. You can alternatively create a latent variable by double-clicking on the model panel, or SHIFT double-click for an observed variable. By default, a double-headed loop is created with each variable, representing addition unique variance of the variable.

When right-clicking on an existing variable, the context menu includes all variable-specific operations. For example, you can change latent variables to manifests or vice versa via the `Change to Manifest/Change to Latent` operation.

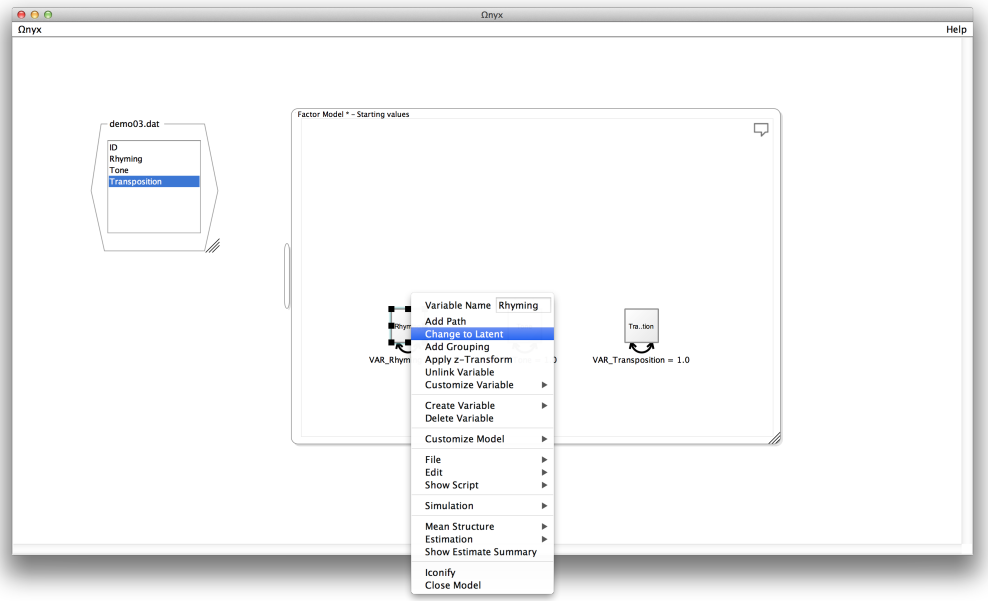

Figure 3.3: Create variables

Constant variables are used to represent means in the model (Figure 3.4). For more complicated models, you can have more than one constant variables in the model to avoid crossing paths.

Figure 3.4: Constant means triangle

The appearance of a variable can be changed by choosing `Customize Variable`, where

Ωnyx also a convenient option to z-transform variables. Right click on a manifest variable and select `Apply z-Transform`. The selected manifest variable is now shown with an inner border (Figure 3.5), indicating that the variable will be z-transformed, i.e., mean centered and divided by its standard deviation, before being used.

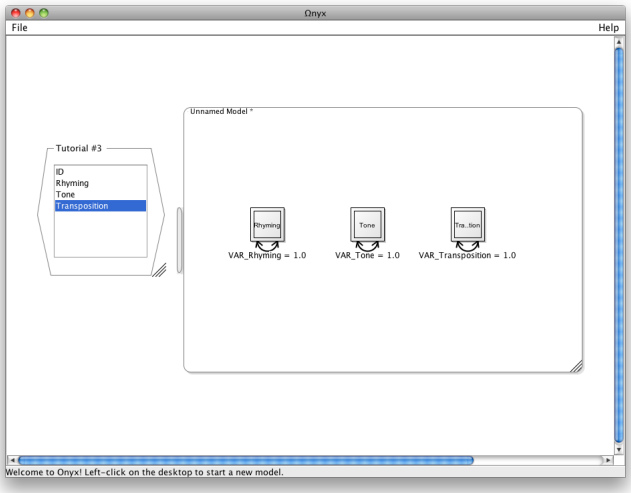

Figure 3.5: z-transformed manifest variables

3.3 Paths

Regression relationships between variables are represented by singe-headed arrows (⟶), whereas variances and covariance relationships are represented by double-headed arrows (↜⇝). Right click on a variable and drag onto another variable; a one-headed arrow will be created from the first to the second variable. Alternatively, select `Add Path` from the context menu of the first variable and select the target second. Paths created in this way will be single-headed regressions. You can hold the SHIFT key while creating the path to make it a double-headed covariance path instead. A covariance path from a variable to itself will create a variance path, indicated by a double-headed loop.

The context menu of the path, reachable by right click on the path, contains path-related operations. These allow you to change the direction

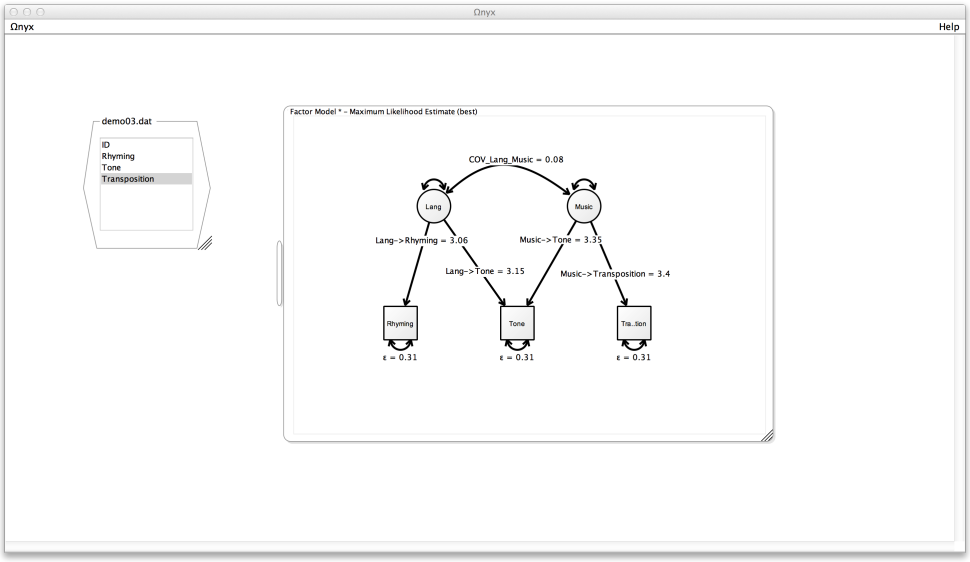

Figure 3.6: Create paths

of the path by choosing `Toggle Path heads`, which cycles through the two possible directions of a single-headed path and a double-headed path. The options `Free Path/Fix Path` allow you to assign either a fixed value to the path or to declare the path value a parameter which will be adopted in the estimation process (see Section 4.2). The fixed value of the path, or the starting value for a free parameterized path, can be entered in the text field `Value` in the context menu. Alternatively, you can hover the mouse over a path and type the value without opening the context menu.

To constrain the parameter of multiple paths to be the same, you can assign the same parameter name to these. In the estimation process, the same parameter name will be treated as the same parameter if it appears on multiple locations (Figure 3.7).

Analogously to nodes, you can alter the appearance of selected paths by choosing `Customize Path` from the context menu of the path.

You can select multiple paths by clicking on all of them while holding the SHIFT button, or by using a selection box on the model panel. If multiple paths are selected, changes to the properties will be applied to all paths at once. So you can for example change the value of multiple paths at once, or constrain parameters to equality by assigning multiple paths the same parameter name.

By default, the parameter name for an edge is displayed if it is freely estimated, while only a number is shown for fixed paths. A fixed path value

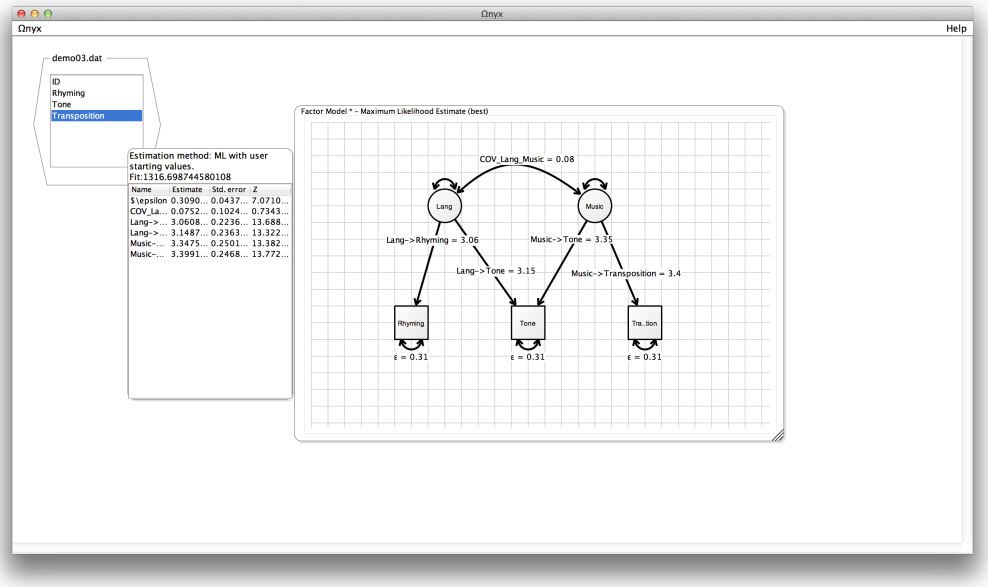

Figure 3.7: Factor model with constrained error terms

of one is not displayed. These defaults can be changed in the model context menu under `Customize Model`.

3.4 Editing models

Parts of models can be selected by a selection box or by choosing `Select All` from the `Edit` menu on model panels. As usual, STRG+A is a keyboard shortcut for selecting all variables and paths. Single elements can be added to or removed from the selection by clicking on them while holding the ALT key down. Selected objects are indicated by a blue glow. As mentioned earlier, manipulations on paths can be done on all selected paths at once. Using STRG plus a number key will collect all selected variables in a *variable group*, which has two functions: Firstly, pressing the same number key at any later time will select or unselect this group again without further need to select the variables. In addition, a path from any variable to a selected variable group will automatically add paths to all members in the group, and analogously for paths out of a group. A connection from a group to itself will create all possible in-group paths.

Selected objects can as usual be copied and pasted. Variable and parameter names in the pasted copy will be renamed automatically. Single

actions can be undone or redone. All these options are available in the `Edit` menu, or via the standard keyboard shortcuts STRG+C and STRG+V or SHIFT+INSERT and STRG+INSERT for copy and paste, and STRG+X and STRG+Y for undo and redo.

Two create a new model panel with an exact copy of the whole model, the `Clone` operation in the `Edit` menu on the model panel can be used. This is particularly helpful to create a restricted version of a model for a likelihood ratio test (see Section 4.4).

3.5 Displaying Scripts, Import, and Export

The path diagram representation used to create models in Ωnyx can be displayed as scripts for multiple other sem programs, including OpenMx (both matrix and ram notation), lavaan, sem, and Mplus, or in other formal SEM representations, in particular RAM matrices and LISREL matrices. To access these scripts, choose `Show Script` in the model's context panel. An external panel will open that provides a script of the model. You may switch between different scripts with the context menu of the script panel. Any changes in the model (e.g., deletion of edges or addition of new nodes) will instantaneously be reflected in the script. Keeping both the graphical and the textual representation next to each other opens a simple way to access the scripting languages for the above mentioned programs, in particular for students in classroom settings.

Using the `File` menu in the model panel, the model can be exported into a script file directly, which can then be used in other programs. Also refer to Section 4.2 to see how Ωnyx can run the scripts directly and use the estimates in the path diagram.

The `File` menu also allows to save the model in the Ωnyx native format, which is an XML format describing the model path diagram (Figure 3.8). This file can at any time be loaded again by dragging the file onto the desktop or by the `Load Model or Data` menu on the desktop.

For publications, the path diagram of the model can be exported in various graphical formats using the `Export Image` operation in the `File` menu of the model panel. These formats include vector graphics or pixel based graphic formats. Alternatively, you can select some or all parts of a model, copy these parts, and paste them in an external graphic program or a slide presentation program, as for example Microsoft Power Point; a graphical representation of the path diagram will directly be exported into those programs for further editing or for presentations.

In addition to the native format, Ωnyx allows to import data from OpenMx

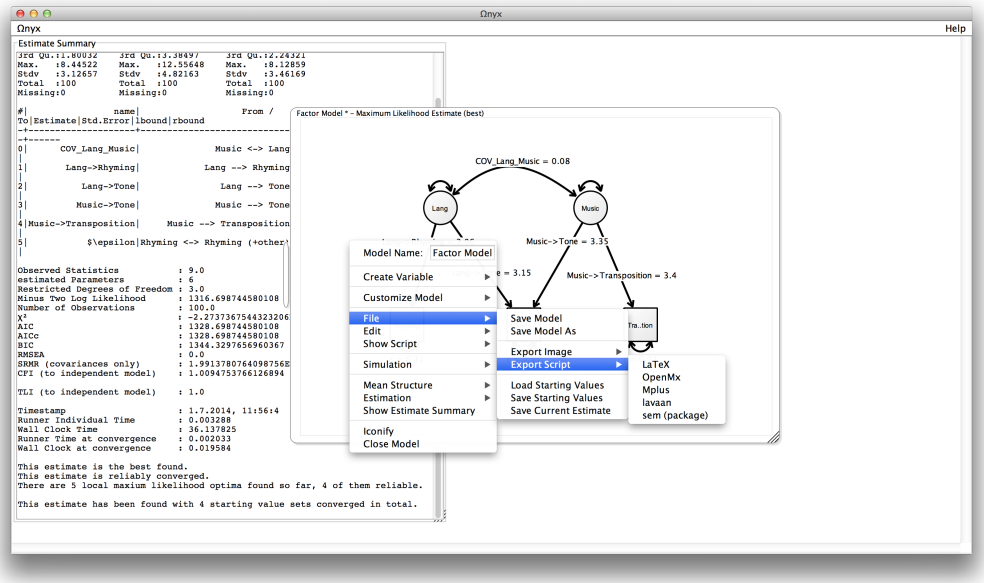

Figure 3.8: Save a model

scripts. The R script has to contain a variable with a value created by the `mxModel` command. Ωnyx runs the script and analyzes this variable to create a model path diagram. The first time R is used, Ωnyx will ask you for the location of R in your file system. An automatic graphical layout for the model is created.

3.6 Definition Variables

3.7 Multi Group Models

You can create multi group models in Ωnyx by specifying the model for each group in a single model frame. Then, choose `Add Grouping` in the context menu of the variables. A small diamond group indicator appears in the lower right of the observed variable. In the variable context menu, you can now specify to which group this variable belongs in the `Group` text field. Group identifiers must be numbers. Again, you can select multiple nodes at once and change the group for all of them simultaneously. Ωnyx will consider the variable only for the data rows where the value of the grouping variable matches the specified group. To link a variable from a data set to a grouping

indicator, see Section 4.1.

3.8 Simulation

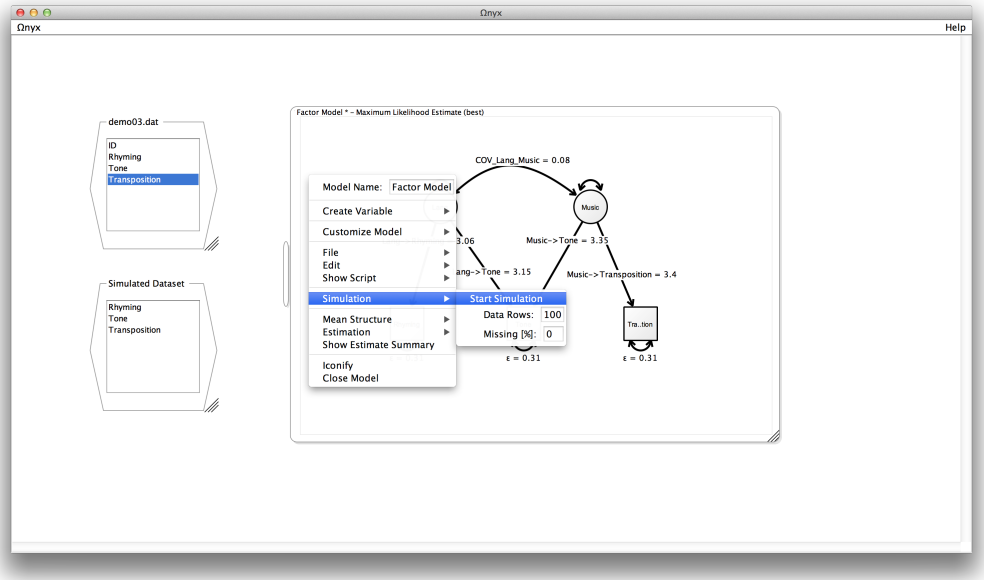

Figure 3.9: Simulate Data

Ωnyx allows to create a data set from a given model via the `Simulation` submenu in the model's context menu. You can select a number of participants and a missing rate in this menu. After that, choosing `Start Simulation` will create a new data set (see Section 4.1 based on the distribution described by the model. The missingness will be added independently and randomly to all variables (see Figure 3.9).

The newly created data set has an additional operation called `Resimulate Data Set (in-place)` in its context menu. This operation will change the data set to a new simulated sample, and can be called repeatedly to create multiple simulation trials (see Figure 3.10).

To save a model diagram into another format (e.g., JPEG, LaTeX), right click on the model panel and click `File | Export Image`. To export a model into corresponding codes for OpenMx, lavaan, sem, or MPlus, click `File | Export Script` (see also Section 3.5).

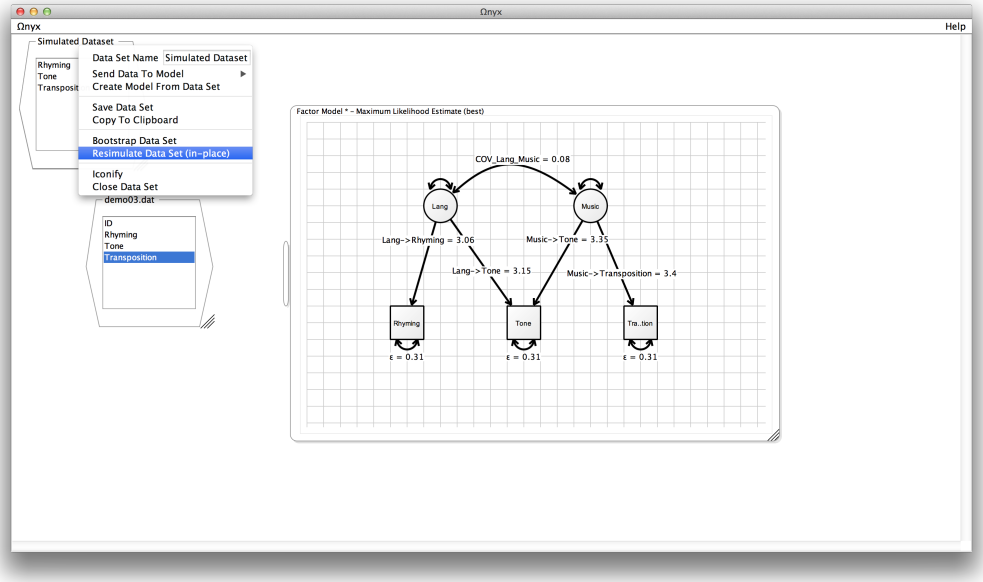

Figure 3.10: Resimulate Data

Chapter 4

Estimation of Model Parameters

4.1 Data Panels

Before Ωnyx can start the estimation process, the model needs to be connected to a data set. To load an existing data set, click `Load Model or Data` in the Ωnyx top menu bar. You can also right click on the workspace and choose `Load Model or Data` from the context menu. If you do not have an existing data set, you can choose `Load tutorial data` on the Ωnyx top menu bar to load a tutorial data set. In the following examples, the tutorial data set `User Guide Factor Example` was used. Alternatively, you can again drag a data file from the file system on the desktop and drop it there. You can also copy a data set in a different program (e.g., Microsoft Excel or a text editor) and choose `Paste` in the context menu of the desktop to directly paste an array of numbers as a data set into Ωnyx . Data files can be tab-separated (`*.dat`), comma-separated (`*.csv`), or SPSS (`*.sav`) files.

Ωnyx allows raw data files and covariance (or distribution) data files. For raw data files, the units of observations (e.g., participants) each have one row, while the columns reflect the variables. The first row can, but does not have to, contain the variable names. Missing values in the data set can be denoted by empty cells, NA, MISS, or -999. Covariance data sets have to contain the keyword `COVARIANCE`, followed by an array of $K \times K$ numbers for K variables containing the covariance matrix of the observed data. The covariance can be written fully or in lower left triangular format. The covariance data set may additionally specify means with the keyword `MEAN` followed by a single row of K mean values. If no means are given, means are assumed to be zero. The keyword `SAMPLE SIZE` followed by a single integer number can be

used to specify the number of participants. By default, this value is one in a covariance data set. Finally, the keyword `OBSERVED VARIABLES` followed by K tab-separated character strings can be used to specify the names of the variables. Only the keyword `COVARIANCE` is required. The keywords can appear in any order.

In Ωnyx , a data set is represented in a hexagonal-shaped Data Panel (Figure 4.1). The columns (variables) in the data set are represented as a list of variables in the data panel. Similar to a model panel (see Section 3.1), a data panel can be *iconified* to save space on the desktop. 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 descriptive statistics (e.g., mean, standard deviation, minimum, maximum) of the particular variable will be shown on a pop-up menu.

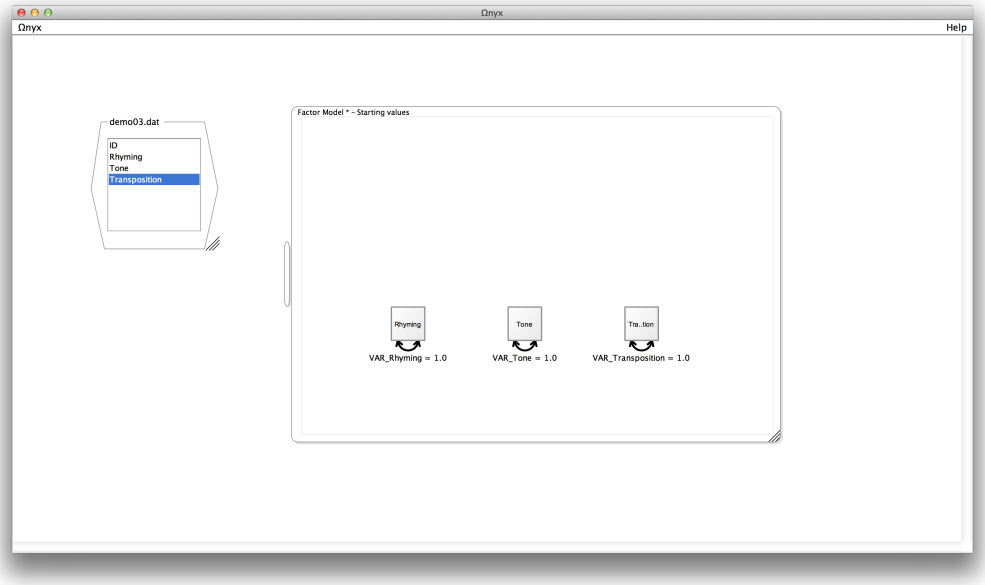

Figure 4.1: Model with no connected data

Left click on a variable on the data panel, and drag it onto the model panel to use it in a model. You can drag a variable on an existing observed variable to link the data variable to this observed variable in the model, or you can drop a variable on an empty space in the model panel to create a new observed variable. A variable that is linked to a data set is indicated by a black border. You can also select multiple variables on the data panel, and drag them onto the model panel (see Figures 4.1 and 4.2).

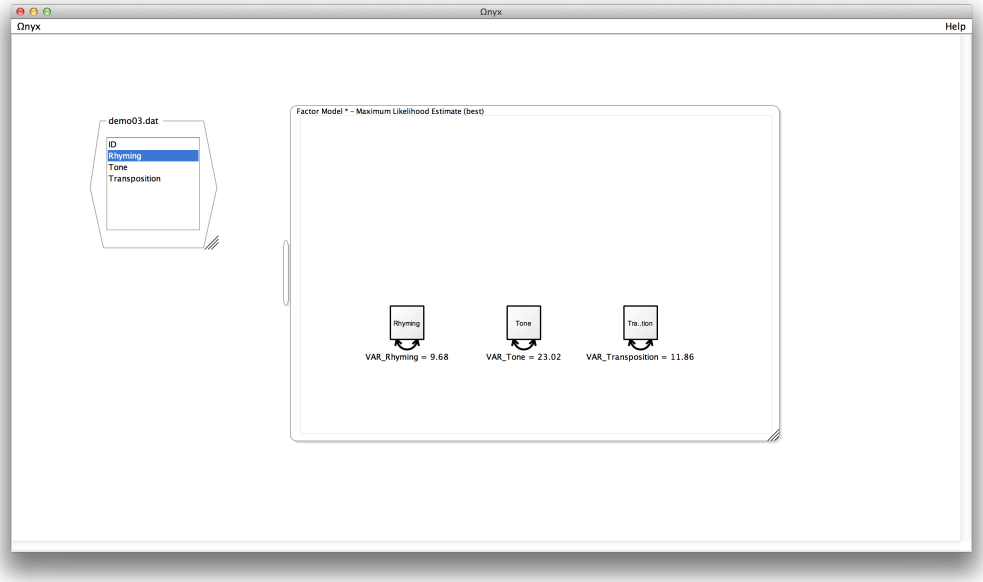

Figure 4.2: Model with connected data

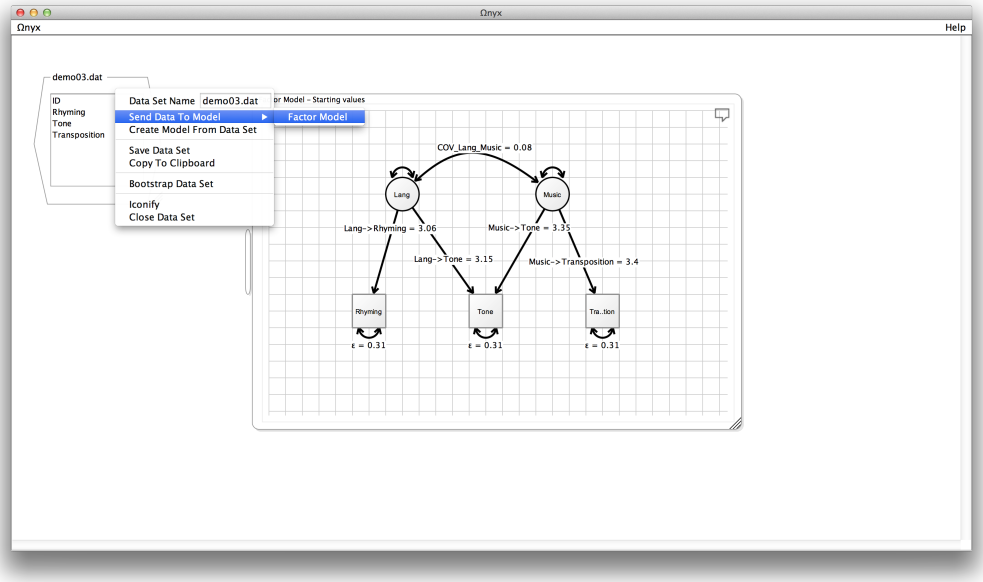

Figure 4.3: Send data to model

Note that you can create models without having a Data Panel; Ωnyx offers several options to connect models with data sets. Using the context menu of the data set, you can choose `Create Model from Data Set` to create a new data set which starts with an observed variables for reach variable in the data set. You can also choose `Send Data to Model` and select on existing model to link all variables in the data set to the model by matching the variable names (see Figure 4.3).

Ωnyx does not provide a in-build editor for data sets, but you can select `Copy to Clipboard` on a data set to copy the content of the data file into another program, as for example Microsoft Excel or another spreadsheet software. You can edit the data there and copy and paste the data set back into Ωnyx . You can also choose `save` to save the data set as a tab separated file.

The context menu also allows you to draw a single bootstrap sample from an existing data set by choosing `Bootstrap Data` from the context menu. This will create a new data set consisting of N draws with replacement from the source data set. The context menu in the new data set has an option `Rebootstrap Data Set (in-place)` that allows to draw new samples at any time.

4.2 Estimation

Once all observed variables in a model are linked to a data set, Ωnyx immediately starts a maximum likelihood estimation that finds the best values for all free parameters to make the model distribution be as close to the data distribution as possible. A tool symbol in the model panel will indicate the process. As soon as a converged result is available, the parameter values for all free parameter will show the estimated result; for small models, this happens mostly instantaneous.

Changes to the model are reflected by simultaneous changes (if any) to the parameter shown in the model. So all changes are directly reflected in the visual representation. To view the estimation result in a table, double-click on the results handle on the left of the model panel to open the *Results Drawer*. It gives a quick overview over all estimated parameters, there standard error, and the z-transformed parameter estimates. You can double-click the results drawer to close it again.

You can also view the summary of the estimated parameters by choosing `Show Estimate Summary` from the model context panel. A complete summary of the estimate will be shown in a separate panel (Figure 4.4), including descriptives of all variables, all parameter estimates, the fit value, and usual

fit indices. You can copy this text, or save it as a text file using the `save` operation from the context menu.

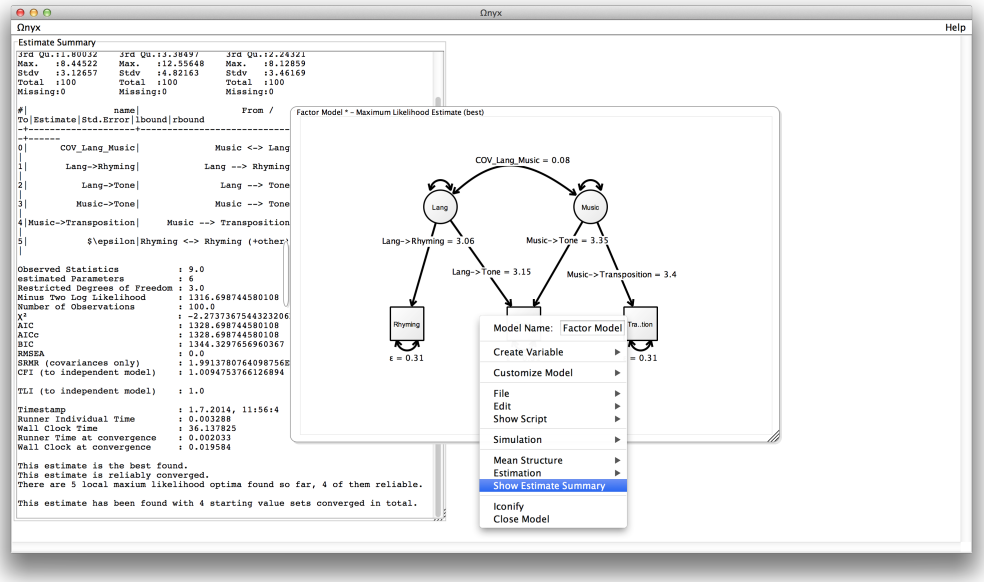

Figure 4.4: Model with estimate summary

The `Estimation` submenu in the context menu of the model panel provides a number of operations related to the estimation process. The `Strategy` menu allows you to select different estimation strategies and different priorities for the estimation process. Researchers interested in the optimization process itself can select `Show Estimation History` to get a tabular overview over all estimation steps taken to reach the maximum likelihood optimum.

Ωnyx starts multiple estimation processes with different starting values in parallel to search the parameter space exhaustively. If one of these estimation processes provides a better likelihood than the one currently shown, this is indicated by a *sparkling* symbol in the upper right corner of the model panel. You can select among all converged estimation processes in the `Select Estimate` list in the submenu `Estimation`. In particular, this list will contain both Maximum Likelihood and Least Square Estimation processes. All estimation processes, even after having reached a convergence criterion, are still running in the background, trying to optimize the result even further where possible, and new estimation processes with randomly picked starting values are constantly launched in the background, even if the first converged result is already displayed.

Converged optimization processes that reached the same minimum are condensed in one, while different local optima are represented as different estimation processes in this list. You can also select the estimation results from this list via the keyboard by typing ALT plus a number; ALT+0 will show the starting values, while ALT+1 to ALT+9 will show the first to ninth option in the list of converged estimates. The operation `Show All Runners` will open a new panel with a list of all estimation process, both converged and non-converged, that are currently run in parallel.

In addition to the native Ωnyx estimation processes with different starting values, you can choose `Start External Estimate` to initiate the estimation process with an outside program, in particular, OpenMx, lavaan, sem, or an older monolithic version of Ωnyx . These programs will be started with the user-provided starting values and be added to the list of converged estimation processes as soon as they return a result. To run the three external packages based on R, you need R installed. The first time Ωnyx needs R, it will ask you for the location of the executable on your file system. Note that external estimation processes are used in a single run-and-return fashion, that is, they will not continue to improve the estimation result once they returned an result. Also, contrary to the native estimation processes, external estimation will not be restarted when the model is revised.

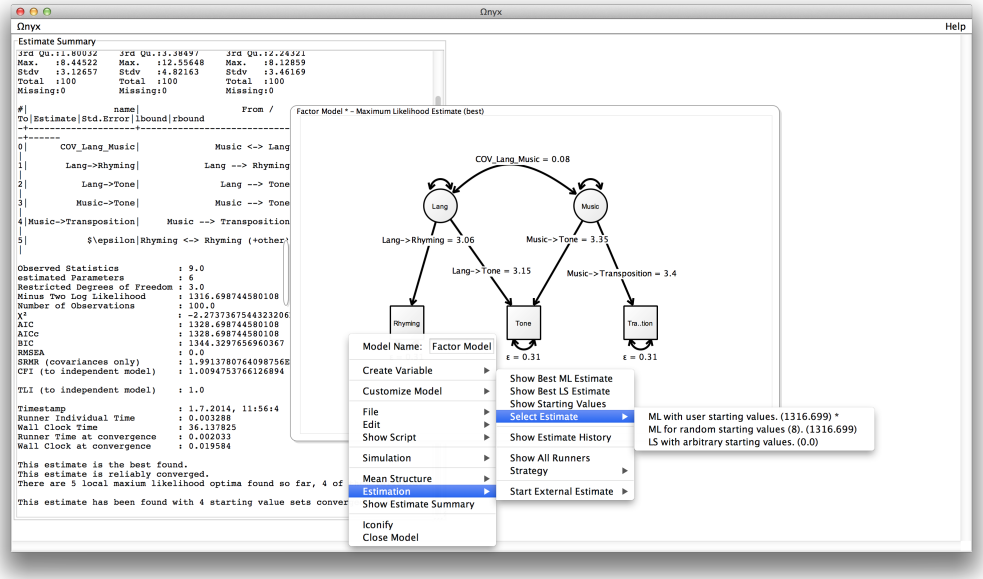

Figure 4.5: Select estimates

4.3 Mean Structure

Ωnyx provides two options for the treatment of data means. You can choose the desired treatment from the `Mean Structure` list in the context menu of the model panel. `Explicit Means` will assume that your model contains all means explicitly, using constant variables. Observed variables that are not connected, directly or indirectly, to a constant variable are assumed to have a fixed mean of zero. This option is advised if your model considers both fixed and random effects.

The `Saturated Mean` structure indicates that all variables will be mean-centered before fitting, which for full data sets coincides with estimating the mean of every observed variable freely. This option is advised if your model is about the covariances of the data, and non-zero means, if any, are not to be considered for the estimation process.

By default, Ωnyx will automatically choose the more appropriate when necessary. In particular, when you start adding variables to an empty model, a saturated model is assumed. As soon as a constant variable is added to the model, Ωnyx will switch to an explicit mean structure. If, on the other hand, variables are connected to the model that have non-zero mean even though no constant variables are used in the model, Ωnyx will assume saturated means. A warning symbol in the upper right corner indicates when this change occurred.

4.4 Model Comparison

Two nested models can be compared in Ωnyx using the Likelihood Ratio (LR) test. 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, you could create a model, clone it using the `Edit` submenu, and fix one or more parameters to zero in the clone. Connect the same data sets to both models. Now, right-click on one model and drag it to the other model, as if creating a path from one to the other model. A dashed line connecting the two model panels appears indicating a LR comparison (Figure 4.6). Hover the mouse over the black dot in the middle of the dashed line, 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. The LR connection between models can also be drawn when the model are iconified, which increases the overview of the user.

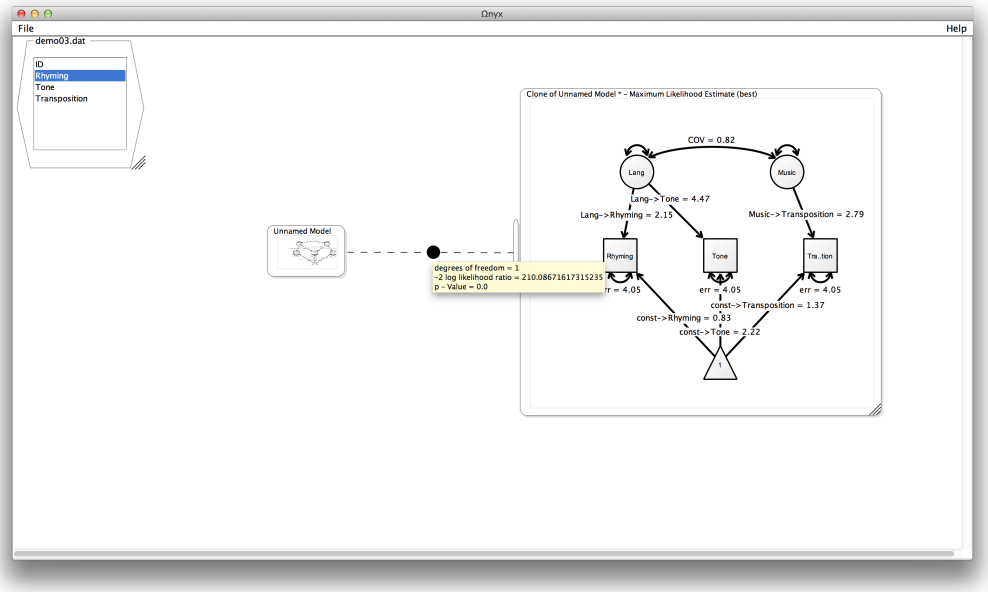

Figure 4.6: Likelihood Ratio test

4.5 Definition Variables

To create definition variables, either right click on a path and choose `Add Definition Variable` to create an unlinked definition variable or drag a variable from a data panel onto a path in a model panel. This creates a linked definition variable. To link an unlinked definition variable, perform the drag and drop action onto the path. To unlink a definition variable, choose `Unlink Definition Variable` from the context menu of the path. To remove a definition variable from a path, choose `Remove Definition Variable`.

Chapter 5

Customization

5.1 Layout

Grid A grid supports you in laying out the components of a graph. Right click on the model panel, click `Customize Model | Change Grid Properties | Display Grid` to show grid; click `Display Grid` again to hide grid (Figure 5.1(. Click `Lock To Grid` to enable snapping new variables to grid. You can also use the keyboard shortcut `CTRL/CMD + G`. In the same menu, the text field `Grid Size` allows you to change the width between grid lines.

Auto layout Right click on the model panel, click `Customize Model | Apply 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 5.2).

Reset The visual reset function resets all variable and path properties to default settings. Right click on the model panel, click `Customize Model | Reset All Elements To Default`. Variables are aligned to the grid and variables are resized into the same size.

5.2 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 a color-wheel window (Figure 5.3(. Similarly, you can customize the color of paths. Right click on a path, click `Change Path Color`. If multiple variables/paths are selected (`shift + left click`), you can customize the color of the selected variable/path group. Furthermore, you can choose

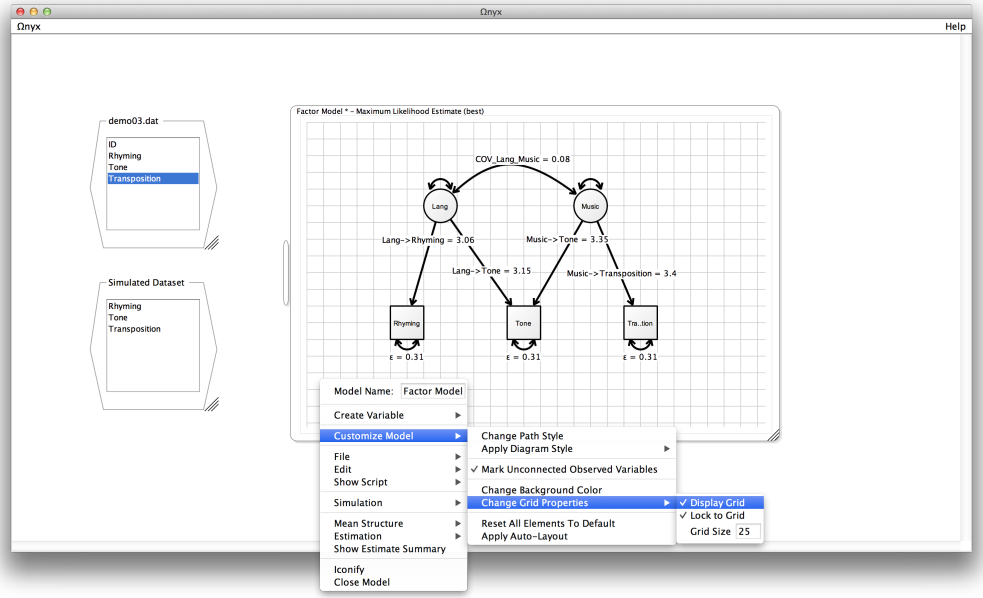

Figure 5.1: Grid display

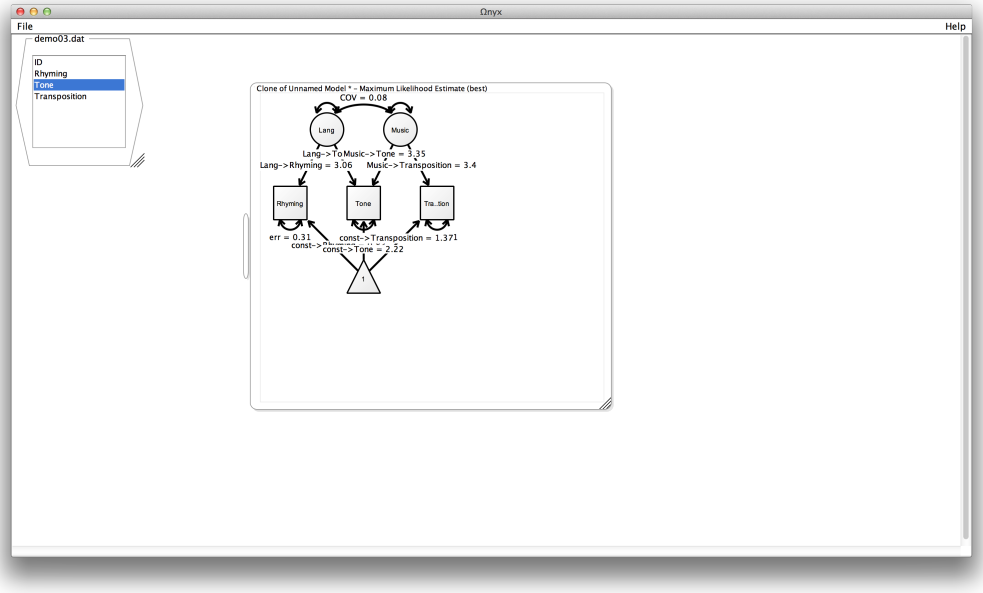

Figure 5.2: Auto layout

between three different fill styles with `Customize variable | Change fill style` to have no fill ("None"), a plain fill ("Plain"), or a shaded fill ("Gradient"). The background color of the model panel can be changed in the menu `Customize Model | Change Background Color`.

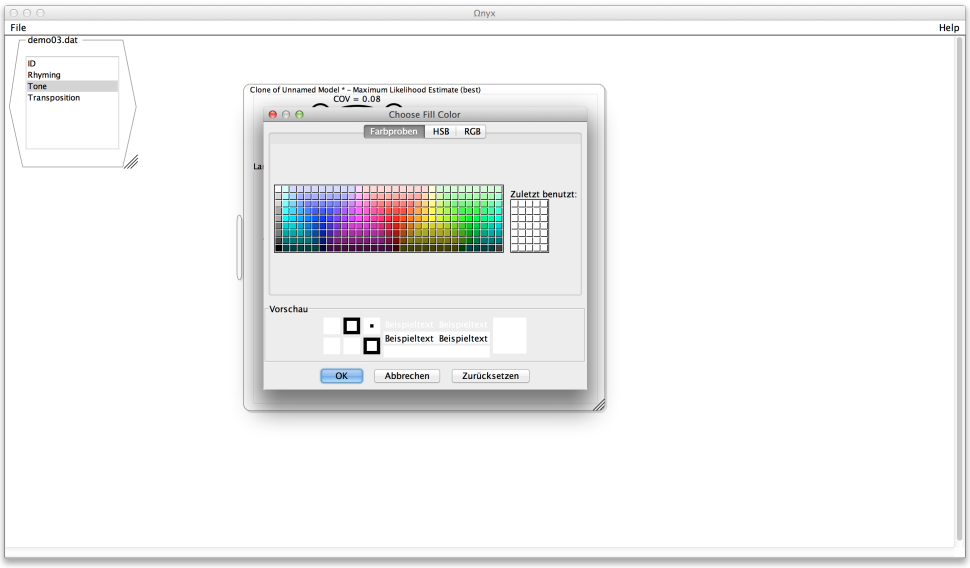

Figure 5.3: Customize color

Graph style Ωnyx provides various styles to quickly reformat your graph. The preset styles can be found in menu `Customize Model -> Apply Diagram Style`. The presets include the 'default' style (gradient fill of nodes, a medium thickness of paths), 'modern' (thin lines, filled arrow heads, plain fill), 'gray' (latents and mean arrows are filled in gray), 'happy' (manifests are blue, latents/means are green, latent residual errors are red), 'modern with dynamic stroke width' (modern theme with stroke width scaled by path weight), retro orange (like happy but with autumn colors), 'metal' (like happy but with blue/gray colors). You can quickly cycle through the set of styles by using the shortcut `Control + L`.

Line weight, arrow heads, and & font size By default, paths are set to `Thickness` = 3, `Font size` = 12. Right click on the model panel, click `Customize Model` and you can customize the line weight and font size of the selected path(s). The arrow heads can be changed in menu `Customize Path | Arrowhead` as `V-Shaped`, `Filled`, or `Pointy`.

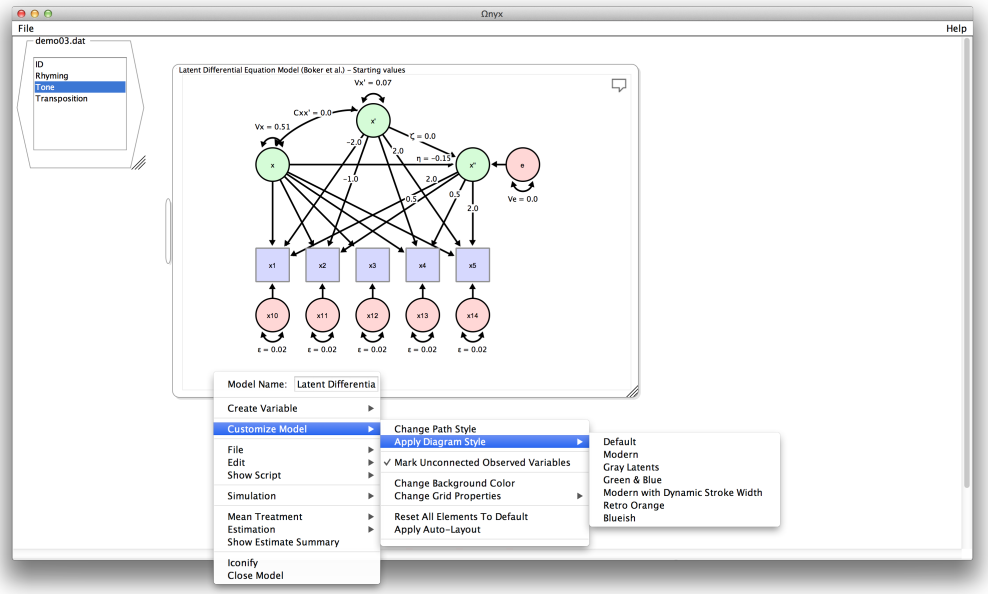

Figure 5.4: A model with applied graph style 'Happy'

Path styles Ωnyx offers several path styles for customization (Figure 5.6). Right click on the model panel, click `Customize Model` | `Change Path Style`. The selected style will be applied to all paths on the active model panel. A checkbox in the bottom row allows the explicit display of the digit '1' on unit path loadings, which by default is surpressed.

Curvature of covariance paths can be controlled by either selecting a path and typing the arrow-up or arrow-down key. More fine-grained control can be achieved by clicking on a selected arrow. This displays two green control points. Dragging these control points changes the curvature of the path (see Figure 5.5).

5.3 Mathematical symbols

Greek letters It is possible to display Greek letters as parameter names in Ωnyx . Type the corresponding codes in the text edit field (see Section 3.3).

Superscripts & subscripts Ωnyx supports a pseudo LaTex input. Both superscript and subscript commands are preceded by a dollar sign symbol ($).

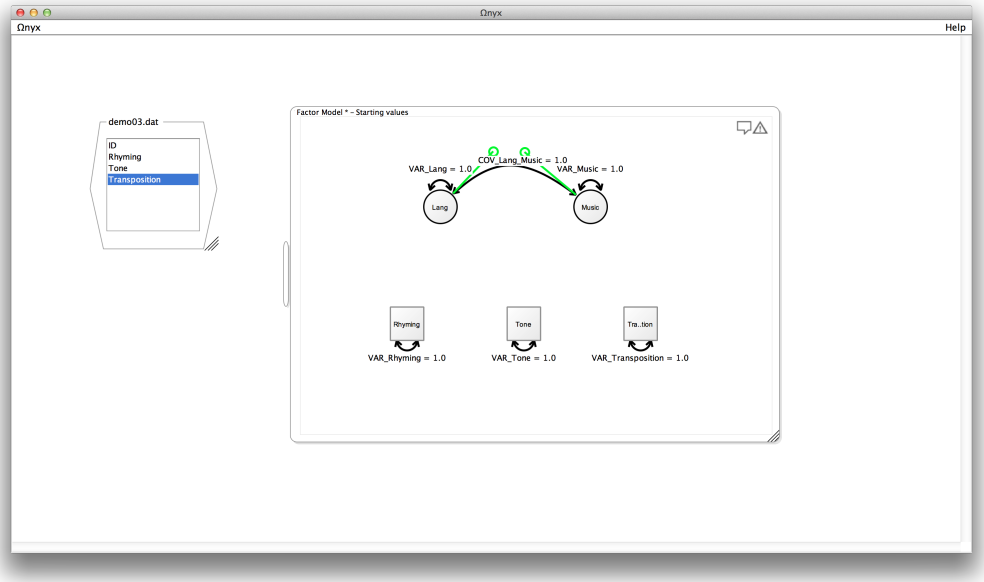

Figure 5.5: Customize path styles

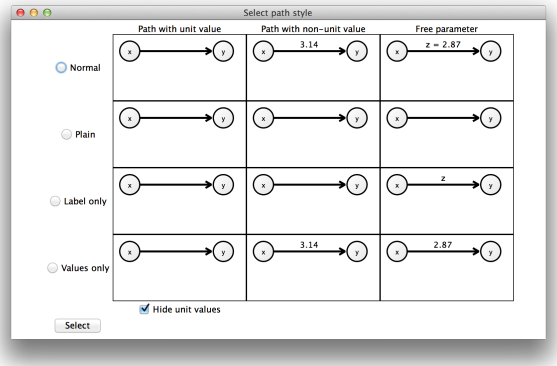

Figure 5.6: Customize path styles

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

Table 5.1: Greek Letters

The superscript command is

`$...^{characters to be superscripted}`

The subscript command is

`$..._{characters to be subscripted}`

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

Ωnyx display	**Command code**
σ^2	$\sigma^2
ρ_{ω}	$\rho_{\omega}
$\omega_{\alpha=1}$	$\omega_{\alpha=1}
σ^2_{X1}	$\sigma^2_{X1}
σ^2_{latent}	$\sigma^2_{latent}
$\lambda_1^{(zero)}$	$\lambda_1^{(zero)}

Table 5.2: Examples for superscript and subscript command

Appendix A

Keyboard Shortcuts

Mac Users, please replace CTRL with CMD key.

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+Y	redo 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+F	flip selected variables vertically
CTRL+SHIFT+F	flip selected variables horizontally
CTRL+S	save model
CTRL+NUMBERKEY	selected nodes are grouped together in a node group. press NUMBERKEY to unselect/select the grouped nodes
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)