GLIMMPSE 2.0.0* USER MANUAL

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***Note: This manual applies to all versions of GLIMMPSE 2.0.X (e.g. 2.0.0, 2.0.1, 2.0.2, etc.).**

1. Introduction
1.1 Welcome to GLIMMPSE 2.0.0
GLIMMPSE 2.0.0 is an open-source online tool for calculating power and sample size. GLIMMPSE has been designed so that researchers and scientists with a variety of statistical training can have access to reliable power and sample size calculations. For optimum usability, GLIMMPSE provides two different modes. In *Guided Mode* users receive step-by-step guided instructions for entering data in order to obtain power and sample size outputs. In *Matrix Mode* users receive less guidance, and are assumed to possess in-depth statistical training.

GLIMMPSE can compute power or sample size for univariate and multivariate linear models with Gaussian errors. GLIMMPSE supports two main types of study design models: designs with only fixed predictors, and designs with fixed predictors and a single Gaussian covariate.*

GLIMMPSE utilizes a Java web services architecture, designed to facilitate future support of additional statistical models. The tool is hosted at *http://www.glimmpse.samplesizeshop.com*.

*Note: The values of a fixed predictor are set as part of the study design, and are known without appreciable error. In contrast, Gaussian covariates are not observed until data is collected. Common designs with only fixed predictors include t-tests, analysis of variance (ANOVA) and multivariate analysis of variance (MANOVA). Common designs that control for a covariate include analysis of covariance (ANCOVA) and multivariate analysis of covariance (MANCOVA).

1.2 Why GLIMMPSE?
Other programs, such as POWERLIB, NQuery, and Pass, also calculate power and sample size. So why use GLIMMPSE?

GLIMMPSE has several advantages over these other programs,because GLIMMPSE is:

1. **Free**. GLIMMPSE provides free online power and sample size computing.
2. **User friendly**. In both *Guided Mode* and *Matrix Mode* GLIMMPSE provides a step-by-step guided interface to assist researchers in producing accurate power and sample size calculations.

GLIMMPSE also:

3. Calculates power and sample size for any univariate or multivariate test for the general linear multivariate model, assuming fixed predictors.
4. Produces confidence intervals on power estimates for designs with fixed predictors.

5. Produces power calculations for designs with a single Gaussian covariate.
6. Supports designs with unequal group sizes, and complicated covariance structures.
7. Creates basic power curves.

2. Using GLIMMPSE

2.1 When to Use GLIMMPSE

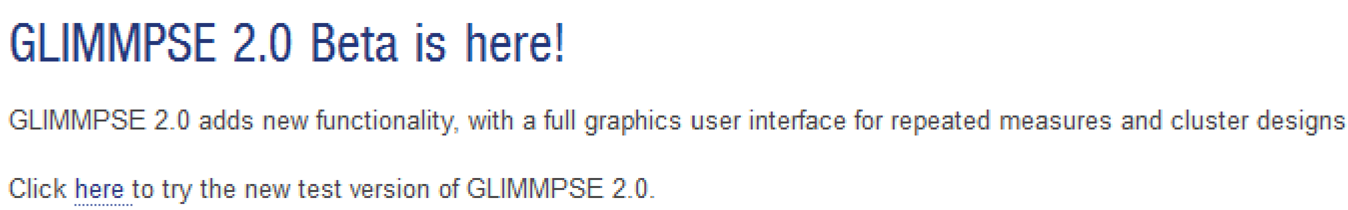
GLIMMPSE helps researchers and scientists determine reliable figures for power and sample size. Currently, GLIMMPSE can calculate power and sample size for the following common statistical tests and models:

- One sample t-test
- Paired t-test
- Two sample t-test
- Analysis of variance (ANOVA)
- Analysis of covariance (ANCOVA)
- Repeated measures analysis of variance
- Multivariate analysis of variance (MANOVA)
- Multivariate analysis of covariance (MANCOVA)
- Linear regression

2.2 How to Use GLIMMPSE

2.2.1 Initiating the GLIMMPSE Wizard

Use a web browser* to access GLIMMPSE at *http://samplesizeshop.com/*. From the home page, click on the *GLIMMPSE* tab, select the *GLIMMPSE 2.0 Beta* page, and click on the test link:



*Note: GLIMMPSE has been tested in Internet Explorer 8 (Microsoft 2012), Mozilla Firefox 13.0.1 (Mozilla 2012), Google Chrome 20 (Google 2012), and Safari 5.0.3 (Apple 2010). For the best experience, Firefox 12.0.1 and Safari 5.0.3 are recommended.

2.2.2 Choosing Between *Guided Mode* and *Matrix Mode*

After clicking on *GLIMMPSE*, three options will be presented: *Guided Mode*, *Matrix Mode*, and *Upload a Study Design.*

In *Guided Mode* users receive step-by-step guided instructions for entering data in order to obtain power and sample size outputs for use in study design. To choose *Guided Mode*, click Select in the *Guided Study Design* box.

In *Matrix Mode* users receive less guidance, and are assumed to possess in-depth statistical training. *Matrix Mode* allows direct input of all matrices required for a power calculation. To choose *Matrix Mode*, click Select in the *Matrix Study Design* box.

If you have a study design saved from a previous GLIMMPSE session, you may upload it by clicking Choose File in the *Upload a Study Design* box. GLIMMPSE will open the saved study and allow you to continue entering the details of your analysis.

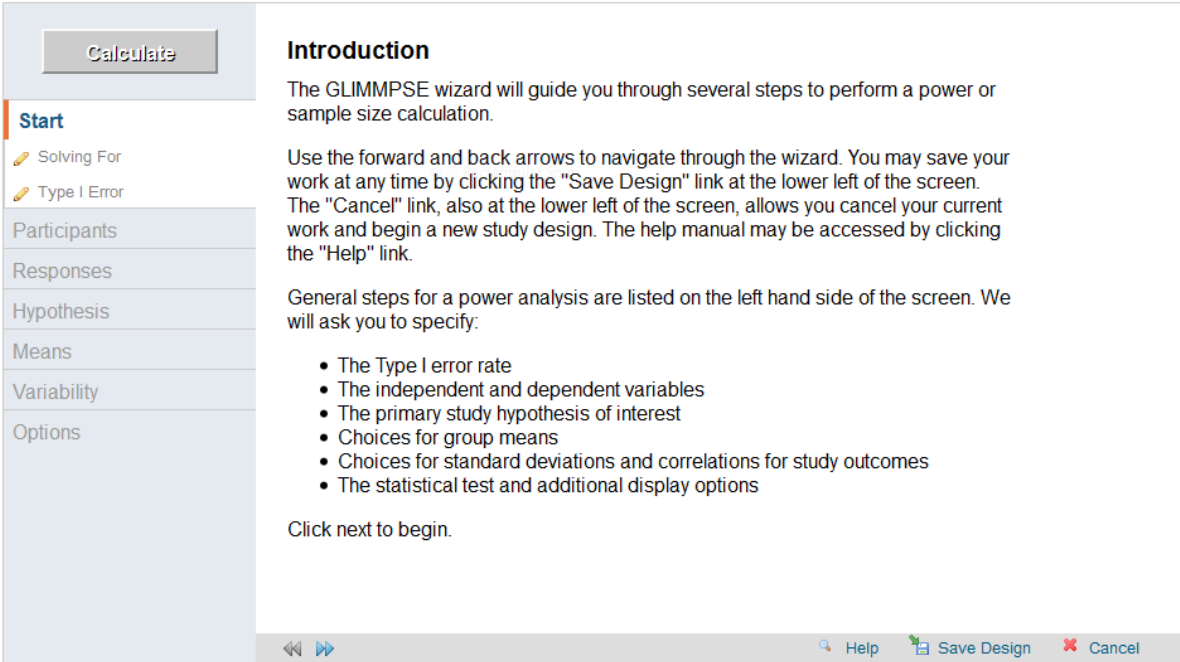
2.3 Basic Navigation for GLIMMPSE in Both *Guided Mode* and *Matrix Mode*

Once a mode of entry has been chosen, the steps required for GLIMMPSE to calculate power are listed as tabs on the left side of the *Introduction* screen. A white background indicates a tab as active, and a blue background designates a tab as inactive. Black text designates a page within a tab as active, and gray designates a page as inactive. Only one page within one tab can be active at a time.

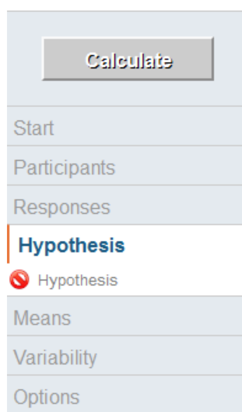
On the bottom right of any screen in GLIMMPSE is a menu of options enabling users to save their study design by clicking Save Design, consult the help library by clicking Help, or cancel without saving and return to the *Start Your Study Design* screen by clicking Cancel.

Each section is broken into one or more sub-sections with the title in bold at the top of the page. Each screen contains instructions and/or areas for user inputs. Users navigate through the sections and sub-sections by clicking  to advance or  to go back. You may also click on the section titles in the panel on the left.

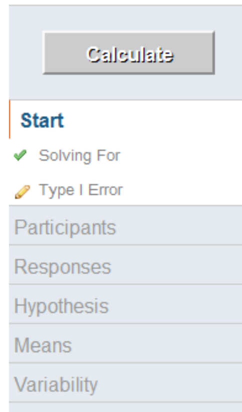
Figure 1: Example Start Screen



Following the *Introduction* screen (Figure 1), GLIMMPSE will prompt you to enter the details for your power or sample size calculation. You may enter the details in any order you wish. However, some screens cannot population unless you enter information into a previous screen. For example, if you have not entered information in the *Participants* tab, you will not be able to enter information in the *Hypothesis* tab. If a tab is closed due to missing information in an earlier screen, it will be indicated by a red circle with a slash through it:



Notice that in Figure 1 there are two pencils beside the two available screens in the active *Start* tab. These pencils indicate screens with required information. Once you have entered the required information, the pencil will turn into a green check mark:



Some screens are optional, and will already have a check mark beside them.

2.3.1 Typing Into a Text Box

At different points while entering data GLIMMPSE will ask you to specify choices for the power or sample size calculation by typing into a text box. To input information in a text box, click in the text box and type the requested information. To complete the entry you may: 1) Click anywhere on the screen; 2) Press Enter on your keyboard; or, 3) Click Add (if available).

To delete entries in a text box, click on the entry so that it becomes highlighted in blue. Click Delete to delete the highlighted entry.

Figure 2 shows three examples of text box entries with the text boxes highlighted in yellow.

Figure 2. Examples of different uses of text boxes

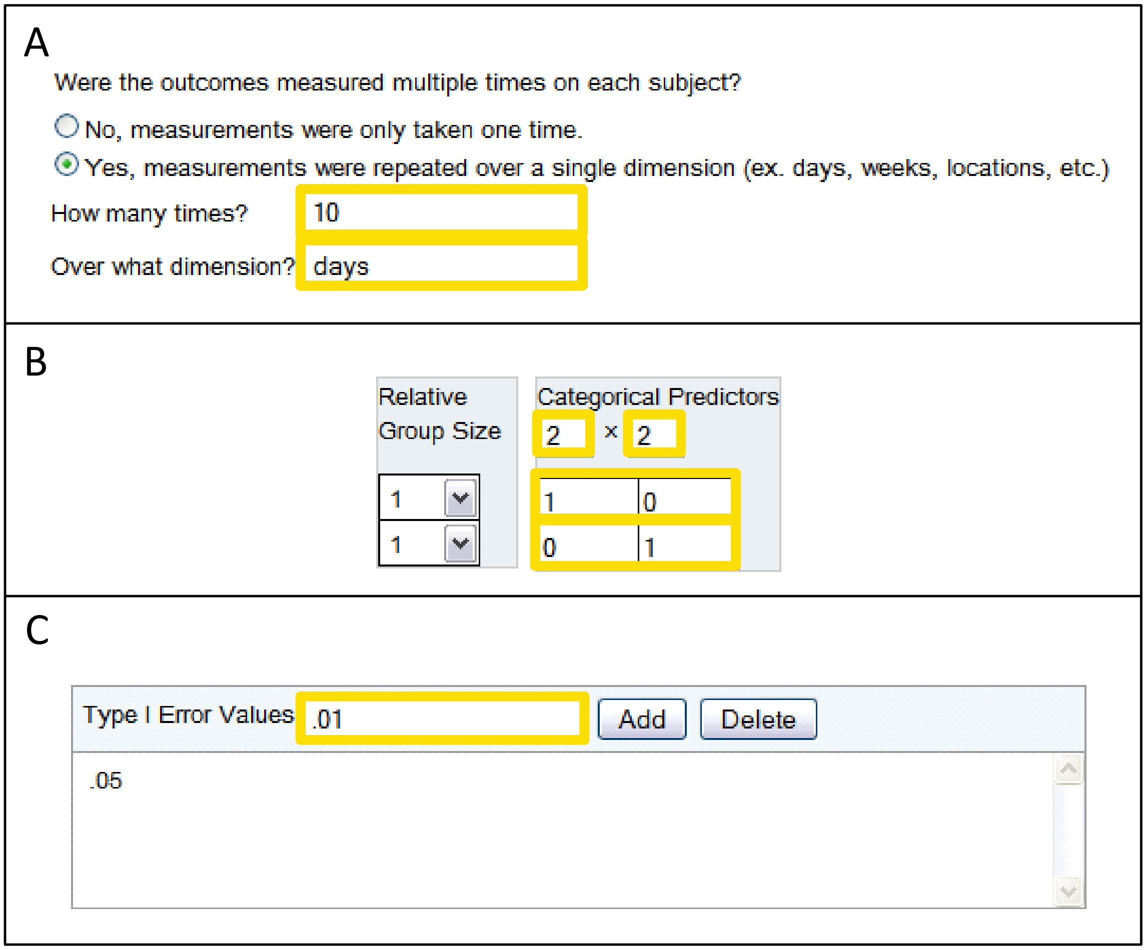
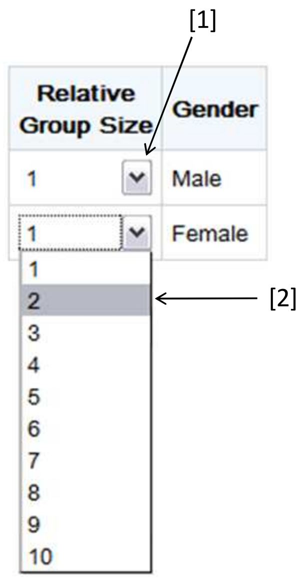


Figure 2: Examples of text boxes that are used to A) collect information on repeated measures, B) specify the size and contents of a matrix, and C) specify one or more choices for an item used in the power calculation.

2.3.2 Using Drop Down Menus

When GLIMMPSE requires you to choose from a defined list of options these options will be presented in a drop down menu. Figure 3 shows an example of a drop down menu. To choose an option from a drop down menu, click on the down arrow (see [1]) then select your choice from the list of options (see [2]).

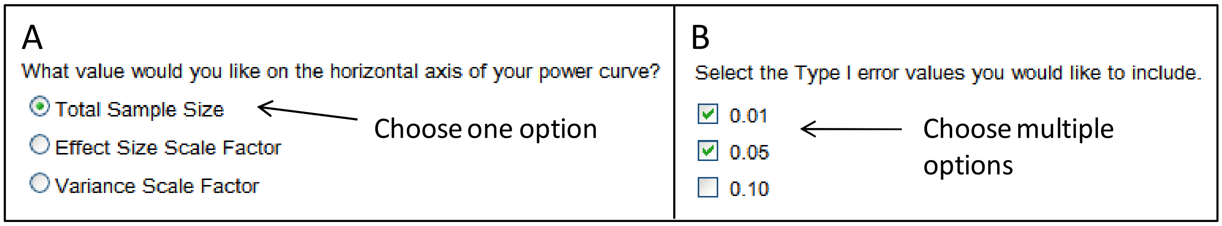
Figure 3. Example of a drop down menu



2.3.3 Radio Buttons and Check Boxes

In some cases, you must choose from a list of options by selecting a radio button or checking a box. The radio buttons allow you to select only one option. The check boxes allow you to select more than one option. To select an option, click on the radio button or check the box next to that option. Figure 4 shows an example of a radio button (see [A]), and a check box (see [B]).

Figure 4. Example of radio buttons and check boxes.



2.3.4 Results Report

Power results are displayed in a table with each row representing an individual power calculation. If multiple factors have been specified in the study design (for example, multiple Type I values, variability scale factors, etc.) then the results table will have multiple rows. See Table 1 below for an example of the information displayed for a given results report.

Every results report for power contains both calculated and desired power values. When solving for power, these two values are the same. When solving for sample size, it may not be possible to achieve the exact power value specified by the user. In this case, *nominal power* is the default power value (the power value specified by the user), and *actual power* is the calculated power for the sample size that best matches the desired power.

A power curve may also be requested, with power on the vertical, or Y, axis and either the regression coefficient scale factor, covariance scale factor, or total sample size on the horizontal, or X, axis.

Power results can be saved to a comma delimited file so that users can import the data into other statistical packages. To save the power results, click Save to CSV beneath the table of results. For transparency, the matrices used in the calculations are accessible on the results screen. To view the exact matrices used in the calculations, click ▶ View Matrices beneath the table of results. This is most useful in *Guided Mode*, where matrix information is largely hidden from the user.

Table 1. Information Displayed for Power Result

Column Name	Description
Test	Name of the statistical test
Actual Power	Calculated power
Total Sample Size	Total number of research participants required to achieve the actual power
Beta Scale	Scale factor applied to the B or B_F matrix
Sigma Scale	Scale factor applied to the Σ_E matrix
Alpha	The Type I error value
Nominal Power	The desired power
Power Method	Indicates whether conditional, unconditional, or quantile power was used
Quantile	If the current power method is quantile power, this indicates the quantile of the distribution of possible powers. Otherwise, this field is empty.
Power Lower	Lower limit of the 95% confidence interval
Power Upper	Upper limit of the 95% confidence interval

2.4 Basic Navigation for *Guided Mode*: Information Specific to *Guided Mode*

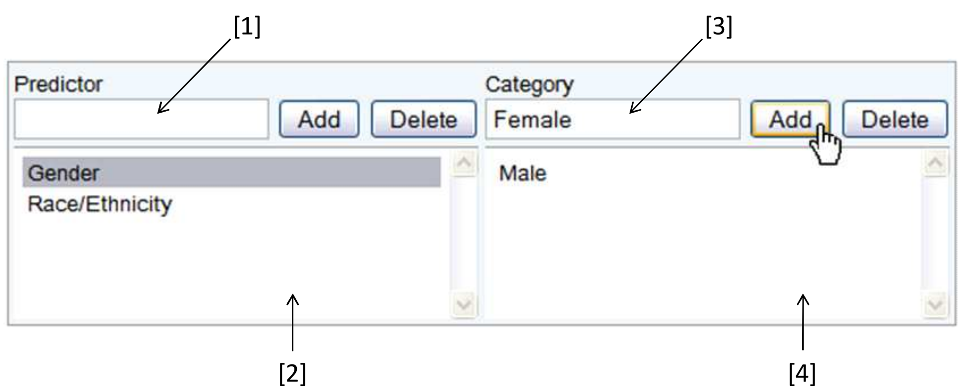
2.4.1 Entering Variables Into a Text Box

In *Guided Mode*, GLIMMPSE asks you to enter labels for your predictor variable(s) (also called independent variables) and your outcome variable(s) (also called dependent variables). Figure 5 shows an example of entering variable labels. To enter a variable label, type the label into the text box provided (see [1] in Figure 5). After each entry, click Add, press Enter on your keyboard, or click anywhere on the screen to populate the field below that text box (see [2] in Figure 5).

For the predictor variables, GLIMMPSE also asks you to specify how many categories each variable contains. For example, the predictor variable "gender" has two categories, "male" and "female." To specify categories associated with a given predictor, select a predictor in the text box on the left (see [2]), then enter the category labels into the text box on the right (see [3] in Figure 5). After each entry, click Add, press Enter on your keyboard, or click anywhere on the screen to populate the category text box (see [4]).

Only category labels associated with the highlighted predictor label are shown. To delete predictors or category labels, select the unwanted label and click Delete. This removes the label from the list. If you remove a predictor, the associated categories are automatically deleted.

Figure 5. Example of entering labels.



In *Matrix Mode* multiple alternatives may be entered directly or they may be specified as scale factors.* Users in *Matrix Mode* may explicitly specify Type I Error rate, effect size, variability, multiple alternatives for power when calculating sample size, and per group sample size when calculating power. Multiple alternative are entered in the same way as information is entered into text boxes (as described above in this section).

*Note: Scale factors are scalar multipliers applied to the quantile values. For scale factors, enter "1" if you want to specify the initial estimate.

2.5 Basic Navigation for *Matrix Mode*: Information Specific to *Matrix Mode*

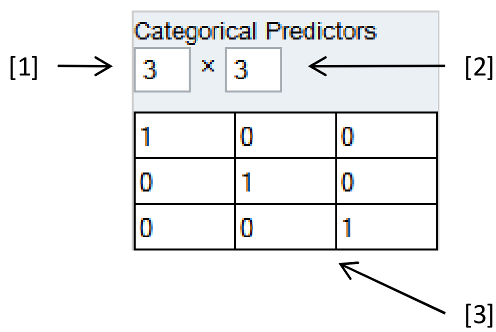
2.5.1 Options in *Matrix Mode* for Defining Your Study Design

In *Matrix Mode*, users may request a list of different power calculations by specifying multiple α levels, selecting several statistical tests, or defining multiple scale factors for the regression coefficients and covariance matrices. In addition, users may specify multiple target power values when solving for sample size, and multiple per-group sample sizes when calculating power. For the General Linear Multivariate Model with Fixed Predictors and a Gaussian Predictor, users may select unconditional power, quantile power, or both. For quantile power, multiple quantiles may be entered.

2.5.2 Resizing and Entering Values Into a Matrix

In *Matrix Mode*, GLIMMPSE requires you to define the matrices used in the power calculation. Figure 6 shows an example of a matrix template in *Matrix Mode*. Sometimes the matrix dimensions are pre-determined. If not, you can set the matrix dimensions by typing the number of rows into the row text box (see [1] in Figure 6) and the number of columns into the column text box (see [2] in Figure 6). Fill in the elements of the matrix by entering values into the text boxes within the matrix template (see [3] in Figure 6).

Figure 6. Example of entering values into a matrix.



3. Using *Guided Mode*: A Screen-by-Screen Tour

In *Guided Mode* users receive step-by-step guided instructions for entering data in order to obtain power and sample size outputs for use in study design.

3.1 Start

3.1.1 Introduction

This screen contains a summary of the steps involved in the power or sample size analysis.

After reading the screen, click to begin entering the details of your study design.

3.1.2 Solving For?

This screen allows you to select either Power or Sample Size for your study design calculation.

If you select Power, your inputs will be used for a power analysis that will produce a value between 0 and 1, representing the likelihood a study will conclude that a given phenomenon occurred. If you select Sample Size your inputs will be used to calculate the number of individual sampling units (also called participants, if referring specifically to people) you need to include in your study to achieve your desired power.

If sample size is set due to budgetary or other restrictions, a power calculation can tell you how likely it is the study will provide a definitive answer to the question of interest. However, if the number of participants is not set, we recommend solving for sample size in order to obtain the appropriate sample size for achieving the goals of your study.

On the screen, indicate whether you would like to solve for Power or Total Sample Size by selecting the appropriate radio button.

When you have completed your selection, click to proceed.

3.1.3 Desired Power (if solving for Total Sample Size)

Enter the target values as decimals, *i.e.* 0.95, in the *Power Values* box.

When you have finished entering the required values, click to proceed.

3.1.4 Type I Error

Enter the target values for Type I Error as decimals, *i.e.* 0.05, in the *Type I Error Values* box. The user may specify up to five Type I Error values.

When you are finished entering your values, click to proceed.

3.2 Participants

3.2.1 Introduction

This screen provides an introduction to the *Participants* section.

After reading the information on the screen, click  to proceed.

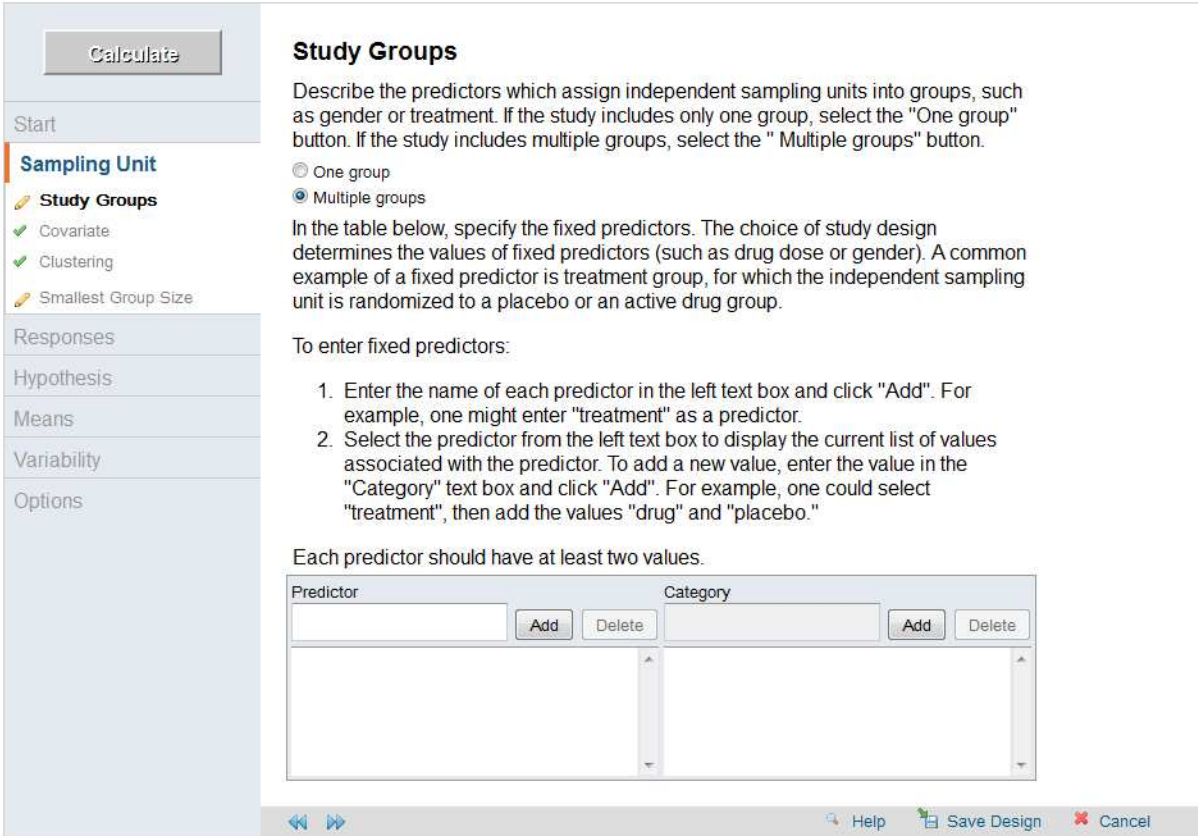
3.2.2 Study Groups

Choose *One sample design* or *One or more fixed predictors*.

A fixed predictor is a contributive factor in the study design considered to be of significance, such as "treatment group" or "gender."

If you select "One or more fixed predictors" you will be presented with further options for specifying the predictors and their categories. The predictors entered will typically be split into two or more categories. For example, for the predictor "treatment group" you might specify the two treatment categories "drug" and "placebo." For the predictor "gender" you might specify the two gender categories "male" and "female."

Figure 7: Study Groups



When you have finished making your selection, click to proceed.

3.2.3 Covariate

This screen allows you to control for a single Gaussian predictor. If your study design does not include a Gaussian predictor, leave the checkbox blank. If your study design does include a Gaussian predictor, check the checkbox.

When you have finished, click to proceed.

3.2.4 Clustering

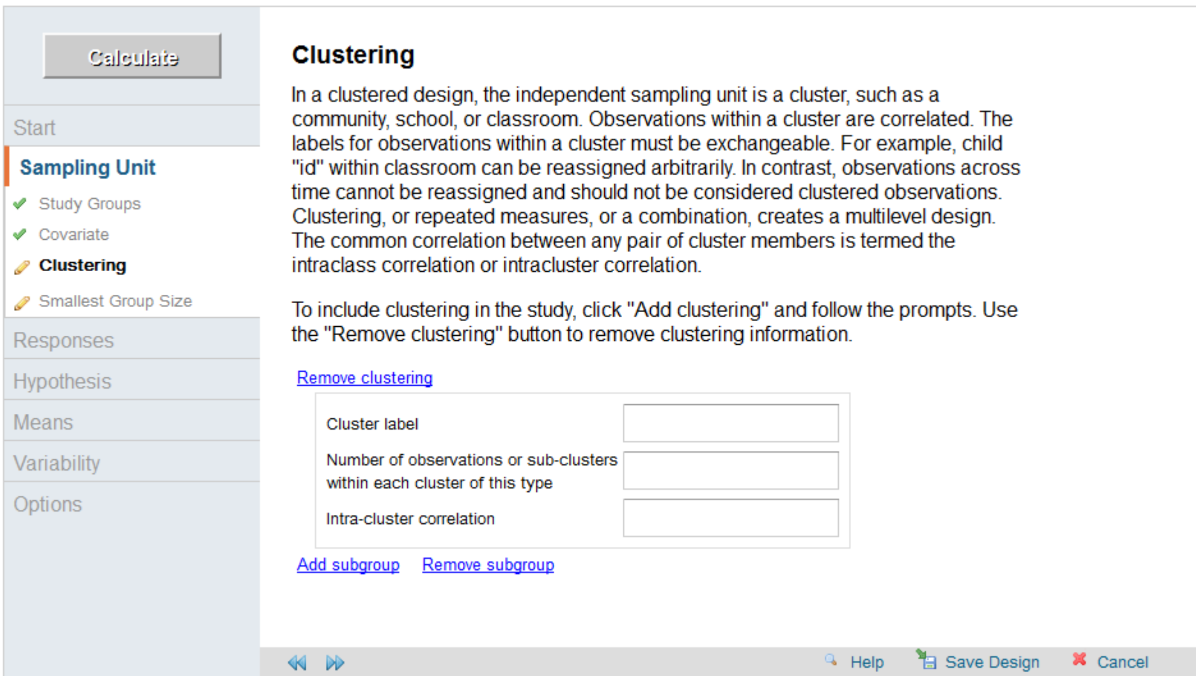
This screen allows you to add clustering. Clustering is present when research participants are organized into groups. Often, randomization in a study occurs at the group level rather than by individual research participants.

If you know that you would not like clustering in your study design, simply click  to proceed. If you know that you would like clustering, click *Add clustering* and follow the prompts.

An example of clustering would be a study design in which the participants are students randomly selected from different schools in an area. In this case, each school would represent a cluster. An example of subgroups within a cluster would be each classroom within a given school.

When you click *Add clustering* three text boxes will appear:

Figure 8: Clustering



Enter the *Cluster name*, specify the *Number of observations or sub-clusters within each cluster of this type*, and specify the *Intra-cluster correlation*. The Intra-cluster correlation is the expected correlation between pairs of observations within the cluster.

To add a subgroup to the cluster, click *Add subgroup* and fill in the information for that subgroup. GLIMMPSE 2.0 allows one primary cluster and two subgroups.

Continuing with the above example, the subgroup *Cluster name* would be "classroom", the *Number of observations* would be the number of students within each classroom and the *Intra-cluster correlation* would be the expected agreement between students within each classroom.

If you would like to remove a subgroup or remove clustering, simply click *Remove subgroup* or *Remove clustering*.

When you have finished entering your values, click to proceed.

3.2.5 Sample Size (if solving for Power)

Enter value(s) for the anticipated sample size of each participant group. Multiple entries allow for multiple outputs of expected power.

When you have finished entering your values, click to proceed.

3.3 Responses

3.3.1 Introduction

This screen provides an introduction to the *Responses* section. After reading the information on the screen, click to proceed.

3.3.2 Response Variables

The *Response Variables* screen allows you to specify the response or dependent variables for your study. For example, if "expected pain" is the desired outcome, enter "expected pain" in the text box.

When you have finished, click to proceed.

3.3.3 Repeated Measures

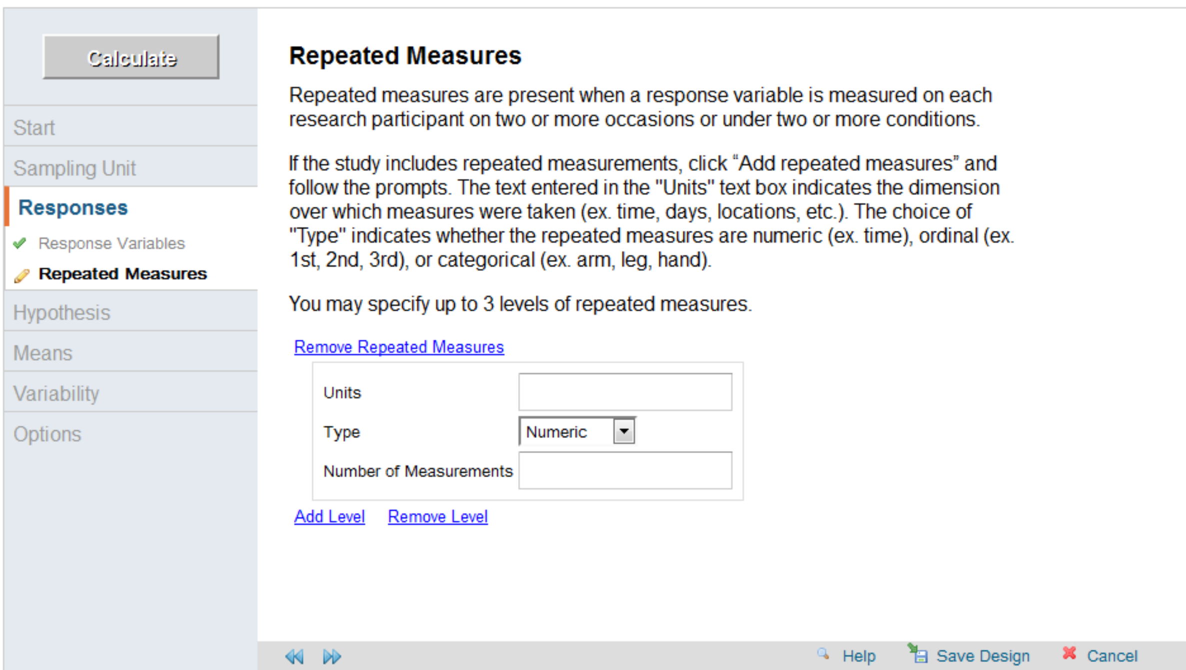
This screen allows you to select repeated measures. If you do not want to use repeated measures in your study design, click to proceed. If you want to use repeated measures, click *Add repeated measures* and follow the prompts.

Repeated measures are present in a study when multiple measurements are taken on each research participant. An example of repeated measures would be researchers taking a participant's blood pressure once a month for six months.

Sub-dimensions for a repeated measure allow for further options within the repeated measure. For example, if a participant's blood pressure is measured every month as the repeated measure, the sub-dimension could be taking the participant's blood pressure in three different positions (for example, standing, sitting, and supine). The *Unit* would be "position", the *Type* could be either ordinal or categorical and the *Number of Measurements* would be three.

When you click *Add repeated measures* three text boxes will appear:

Figure 9: Repeated Measures



Units is a user-specified description of the repeated measure. For example, if the repeated measures are taken once every month, the unit could be "month." Enter a label for the units of the repeated measure.

Enter the *Type* of unit. For *Numeric* repeated measures, both the distance and ordering between measurements is meaningful. Measuring blood pressure every month for 6 months is a numeric repeated measure. GLIMMPSE 2.0 will auto-populate an equal distance between repeated numeric measures. You can change the distance between the measures by typing into the text boxes. For *Ordinal* repeated measures, the ordering of the measurements is meaningful, but the distance between measurements is assumed to be equal. For example, repeated measures of heart rate in the morning, afternoon, and evening. For *Categorical* repeated measures, neither the ordering nor the distance between the measures is meaningful. For example, repeated measures of breast density using three different instruments, Device A, B and C.

Number of Measurements allows you to specify the number of times the repeated measure will be taken. For the blood pressure example, the *Number of Measurements* would be 6 since blood pressure was measured every 6 months. For numeric repeated measures, GLIMMPSE 2.0 auto-populates equidistant measurements. To change the distance between measures, type into the text boxes. For example, if blood pressure was measured every month for the first three months then every other month for the next six months the user would type 1, 2, 3, 5, 7, 9 into the text boxes.

If you would like to include a sub-dimension to the repeated measure, click *Add a Sub dimension* and fill in the information, as described above.*

If you would like to remove a sub-dimension or remove the repeated measures, click *Remove Sub-dimension* or *Remove Repeated Measures*.

*Note: Only three sub-dimensions are allowed in GLIMMPSE 2.0.

Once you have made all of your entries, click to proceed.

3.4 Hypotheses

3.4.1 Introduction

This screen provides an introduction to the *Hypothesis* section. After reading the information on the screen, click to proceed.

3.4.2 Hypotheses

The *Hypotheses* screen allows the user to select the primary hypothesis of interest.

If *Main Effect* is selected as your hypothesis, you will be asked to specify one predictor of interest. Once you have selected your predictor of interest, click to proceed.

If *Interaction* is selected as your hypothesis, you will be asked to specify one predictor of interest. Once you have selected your predictor of interest, click to proceed.

If *Trend* is selected as your hypothesis, you will be asked to specify one predictor of interest. In addition, you will be asked to select the type of trend you wish to test from a list of six options.

To learn more about these options, consult the Help manual.

When you have finished selecting your hypothesis and entering your values, click to proceed.

3.5 Means

3.5.1 Introduction

This screen provides an introduction to the *Means* section. After reading the information on the screen, click to proceed.

3.5.2 Mean Differences

Enter the mean values you expect to observe for each outcome within each study subgroup. Differences between the entered means typically represent the smallest clinically relevant difference. The table should contain at least one value that is non-zero.

When you have finished entering your values, click to proceed.

3.5.3 Beta Scale Factors

The *Beta Scale Factors* screen allows the user to choose to compute the means as specified, the mean values divided by 2, and the mean values multiplied by 2.

When you have finished entering your values, click to proceed.

3.6 Variability

3.6.1 Introduction

This screen provides an introduction to the *Variability* section.

After reading the information on the screen, click to proceed.

3.6.2 Within Participant Variability

The *Within Participant Variability* screen allows the user to enter the expected standard deviations for the study outcome, stratified by the predictor variables (i.e., treatment group, gender, etc.).

For a given research participant, responses may vary across repeated measurements and for different response variables. The amount of variability can dramatically impact power and sample size. For each within participant factor and response variable, describe the variability you expect to observe.

When you have finished entering your values, click to proceed.

3.6.3 Sigma Scale Factors

While GLIMMPSE requests standard deviations, it actually computes variances when it conducts the power or sample size calculations. There may be considerable uncertainty about what standard deviation or variance value to use. To account for this uncertainty, it is common to calculate power or sample size using alternative values for variability. The *Flexible Variability* screen allows you to compute power for half the variance, the variance as specified, and twice the variance. This generates scale factors of 0.5, 1, and 2 for the covariance matrix. If you wish to have a range of variances, check the checkbox.

When you have finished entering your values , click to proceed.

3.7 Options

The *Statistical Tests* screen allows the user to select one or more statistical tests for which to compute sample size. Check one or more of the boxes to indicate your desired statistical test(s).

When you have finished , click to proceed.

3.7.1 Statistical Tests

Select the statistical test(s) to include in your calculations.

When you have finished making your selection(s), click to proceed.

3.7.2 Power Method

This screen allows you to select which power method(s) you would like to use. After you have selected your power method(s), click to proceed.

3.7.3 Confidence Intervals

This screen allows you to choose whether or not to calculate confidence intervals for the power estimate. Click the checkbox if you do not want confidence intervals.

Click to proceed.

3.7.4 Power Curve

A power curve describes the change in power (Y axis of the power curve) relative to the total sample size, regression coefficient scale factor, or the variability scale factor (all options for the X axis of the power curve).

Click the box if you want to create a power curve.

Click to proceed.

3.8 Calculate

Click Calculate to receive the results of your power analysis.

For detailed information regarding the Results Report, refer to section 2.3.4 above.

4. *Matrix Mode* Screen-by-Screen Tour*

In *Matrix Mode* users receive less guidance than in *Guided Mode*, and are assumed to possess in-depth statistical training. *Matrix Mode* allows direct input of all matrices required for a power calculation.

4.1 Start

4.1.1 Introduction

Read the summary of the steps involved in the power analysis.

Click to begin entering the details of the analysis.

4.1.2 Solving For?

Indicate whether you would like to solve for power or sample size by selecting the appropriate radio button.

When your selection is complete, click to proceed.

4.1.3 Desired Power

If solving for sample size, this screen will be presented to specify the target values for power. If solving for power, this screen will not appear.

Enter the target values as decimals, *i.e.* 0.95, in the *Power Values* box.

When finished entering your values, click to proceed.

4.1.4 Type I Error

The user may specify up to five α values. Enter the target values as decimals, *i.e.* 0.05 or 0.01, in the *Type I Error Values* box.

After entering your values, click to proceed.

4.2 Design

4.2.1 Design Essence

In the *Design* section, you will define the composition of your study by specifying the number of groups, how subjects are divided into groups, the size of each group, and whether you will include a Gaussian covariate.

The Design Essence Matrix

In the General Linear Multivariate Model with Fixed Predictors regression equation, $\boldsymbol{Y} = \boldsymbol{XB} + \boldsymbol{E}$**,** and the X matrix represents the study design. The same is true for $\boldsymbol{F}$ in the General Linear Multivariate Model with Fixed Predictors and a Gaussian Predictor. For simplicity, we will only discuss $\boldsymbol{X}$ **(**since the instructions do not change for $\boldsymbol{F}$**)**. In data analysis, the $\boldsymbol{X}$ matrix would contain a single row for each subject. Since power analysis does not include actual data, the design "essence" matrix is a version of the $\boldsymbol{X}$ matrix that contains a single row for each unique combination of predictors in the study design. Note that the essence matrix specifies only the fixed, or categorical, predictors in the study design.

For example, consider a 2-factor ANOVA design with 2 levels per factor, 3 subjects per group and a cell means coding. In data analysis, the design matrix and corresponding essence matrix would be:

$$\boldsymbol{X} = \begin{pmatrix} 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 \\ 1 & 0 & 0 & 1 \\ 1 & 0 & 0 & 1 \\ 1 & 0 & 0 & 1 \\ 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 \end{pmatrix}, \quad \boldsymbol{X}\text{"essence"} = \begin{pmatrix} 1 & 0 & 1 & 0 \\ 1 & 0 & 0 & 1 \\ 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 \end{pmatrix}$$

GLIMMPSE requires that the design coding is full rank.

After entering the desired dimensions for your matrix in the top two boxes (the left box contains row values, and the right contains column values), click anywhere on the screen for the matrix to be resized.

When you have completed the matrix, click  to proceed.

4.2.2 Covariate

Currently, GLIMMPSE only performs power calculations for categorical predictor variables. However, a single, continuous, normally distributed predictor variable may be included in the analysis.

To include such a predictor, click the check box next to *Control for a single Gaussian predictor* at the bottom of the screen.

When you are finished, click  to proceed.

4.2.3 Sample Size (this screen only appears when solving for Power)

When solving for power, this screen will request one or more per group sample size(s) from the user. If solving for sample size, this screen will not appear.

The per group sample size is the expected number of participants to be recruited into the study for each experimental group. For unequal group sizes, specify the number of study participants in the smallest group.

To enter one or more per group sample size, type the sample size in the *Per Group Sample Size* box. After each entry, click Add, press Enter on your keyboard, or click anywhere on the screen. To delete a value, select the unwanted value and click Delete to remove the value from the list.

When finished entering your values, click  to proceed.

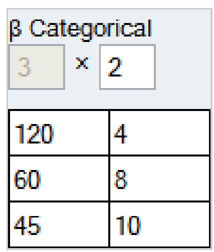
4.3 Coefficients

4.3.1 Beta Coefficients: B Matrix

This section requires possible values for the hypothesis test, $\Theta = CBU$.

In the General Linear Multivariate Model with Fixed Predictors regression equation, $Y = XB + E$, the B matrix represents the proposed relationship between the predictor variables, X, and the outcome variables, Y. The same is true for B_F in the General Linear Multivariate Model with Fixed Predictors and a Gaussian Predictor. For simplicity, we will only discuss B (since the instructions do not change for B_F). To calculate power, estimate the possible values of the regression coefficients for each unique combination of predictors in the study design. The row dimension of B is determined by the number of columns in the essence matrix. Change the column dimension of B to match the intended number of outcomes in the study, or the rows of Y in the General Linear Multivariate Model with Fixed Predictors regression equation.

For example, an investigator may want to compare vitamin D and calcium levels of children who live in three different regions: urban, suburban, and rural. The B matrix would have three pre-specified rows, one for each region, and two columns, one for vitamin D and one for calcium. To calculate power, the investigator must estimate the expected mean vitamin D (column 1) and calcium (column 2) levels of the children in the rural (row 1), suburban (row 2), and urban (row 3) regions. The investigator may estimate $B = \begin{bmatrix} 120 & 4 \\ 60 & 8 \\ 45 & 10 \end{bmatrix}$, appearing as:



.

Enter the number of columns, or the number of outcomes in the study, in the column text box (right) under β Categorical. Press Enter on your keyboard or click anywhere on the screen to resize the blank matrix. Enter proposed values of the B coefficients in their corresponding spots in the β Categorical matrix.

When you have completed the matrix, click  to proceed.

4.3.2 Beta Scale Factors

GLIMMPSE allows users to specify scale factors for the $\boldsymbol{B}$ matrix in order to generate power or sample size values for different coefficient values.* Since power is based on proposed regression coefficients, it is common to calculate power for the proposed value, as well as alternative values such as half and twice the proposed value.

In the *B Matrix Scale Factors* box one or more scale factor(s) for the $\boldsymbol{B}$ matrix may be specified for inclusion in the power calculation. For example, to calculate power for regression coefficients which are half the values in your $\boldsymbol{B}$ matrix, enter 0.5. To use the exact $\boldsymbol{B}$ matrix specified, enter a 1. After each entry, click Add, press Enter, or click anywhere on the screen. To delete a value, select the unwanted value and click Delete to remove the value from the list.

When finished entering your values, click to proceed.

*Note: In the General Linear Multivariate Model with Fixed Predictors and a Gaussian Predictor, the scale factor only applies to B_F, and does not scale the B_g matrix.

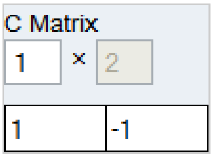
4.4 Hypothesis

4.4.1 Between-Participant Contrast

In this section, you will define the contrast matrices in your study. The contrast matrices, $\boldsymbol{C}$ and $\boldsymbol{U}$, consist of the hypotheses to be tested in your study. They are used to calculate the estimated hypothesis matrix, $\boldsymbol{\Theta} = \boldsymbol{CBU}$.

Between-Subject Contrast Matrix: C

The $\boldsymbol{C}$ matrix consists of the between-subject contrasts. The between-subject contrasts are the hypotheses you wish to test on subjects within different groups. The number of rows in the $\boldsymbol{C}$ matrix represent the degrees of freedom for the hypothesis test. For example, suppose an investigator wants to compare the average final exam test scores of students in class A and class B. The contrast matrix would be $\boldsymbol{C} = [1 \; -1]$, appearing as:



.

When multiplied by $\boldsymbol{B}$, this becomes the difference in the proposed average test scores between class A and class B.*

Enter the number of rows/number of contrasts in the study, in the row text box (left) under C *Matrix*. Press Enter on your keyboard or click anywhere on the screen to resize the blank matrix. Fill in the contrasts you wish to test in the matrix.

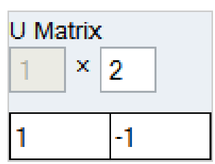
When you have completed the matrix, click to proceed.

*Note: The number of rows in the $\boldsymbol{C}$ matrix cannot exceed the number of rows in the essence matrix minus 1. In addition, the $\boldsymbol{C}$ matrix must conform to the $\boldsymbol{B}$ matrix, so the number of columns cannot be adjusted on this screen.

4.4.2 Within-Participant Contrast

The $\boldsymbol{U}$ matrix consists of the within-subject contrasts. The within-subject contrasts are the hypotheses that compare measurements on the same subjects.

This matrix is most useful for multivariate designs and repeated measures. For example, suppose an investigator wants to examine whether student test scores improve from their midterm exams to their final exams. The investigator would have two measurements per student, one for the midterm and one for the final. The within-subject contrast matrix would be $\boldsymbol{U} = [1 \ -1]$, appearing as:



.

This matrix contrasts two different test scores, the midterm and the final, for the same student.*

Enter the number of columns, or the number of within-subject contrasts, in the study, in the column text box (right) under *U Matrix*. Press Enter on your keyboard or click anywhere on the screen to resize the blank matrix. Fill in the contrasts you wish to test in the matrix.

When you have completed the matrix, click to proceed.

*Note: The $\boldsymbol{U}$ matrix must conform to the $\boldsymbol{B}$ matrix, so the number of rows cannot be adjusted on this screen.

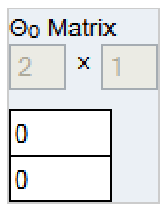
4.4.3 Null Hypothesis

In this section, define $\boldsymbol{\Theta_0}$, the null hypothesis matrix of your study.

Null Hypotheses: Θ_0

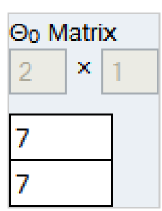
The null hypothesis matrix, $\boldsymbol{\Theta_0}$, represents the test values you would expect to observe when the null hypothesis is true, *i.e.*, when the factors being tested have no relation to the outcome. When performing a power analysis, the values for your hypothesis tests are calculated as $\boldsymbol{\Theta} = \boldsymbol{CBU}$, and then compared against $\boldsymbol{\Theta_0}$. Commonly, $\boldsymbol{\Theta_0}$ is a matrix of zeroes.

For example, suppose an investigator wants to compare resting metabolic rate between subjects with HIV lipoatrophy, subjects with HIV only, and healthy controls. The null hypothesis of no difference between the three groups is $\boldsymbol{\Theta_0} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$, appearing as:



.

Sometimes, however, the null hypothesis is based on previous studies or clinical experience. For example, suppose an investigator wants to compare foal birth weight between dams who are given feed formula A, feed formula B, and standard feed. In order to be cost effective, the new feed formulas must improve foal birth weight by more than 7 kg. The null hypothesis, then is $\boldsymbol{\Theta_0} = \begin{bmatrix} 7 \\ 7 \end{bmatrix}$, appearing as:



.

Fill in the contrasts you wish to test in the matrix.*

When you have completed the matrix, click  to proceed.

*Note: $\boldsymbol{\Theta_0}$ has the same number of rows as $\boldsymbol{C}$, and the same number of columns as $\boldsymbol{U}$. Therefore, its size cannot be adjusted on this screen.

4.5 Variability

4.5.1 Error Covariance

Variability describes how much measurements differ from each other. The covariance matrix $\boldsymbol{\Sigma}_{\boldsymbol{\epsilon}}$ describes the variability of measurements between and within each factor in your analysis. In this section, you will propose values for $\boldsymbol{\Sigma}_{\boldsymbol{\epsilon}}$.

Covariance of Outcomes: Σ_ϵ

The error covariance matrix $\boldsymbol{\Sigma}_{\boldsymbol{\epsilon}}$ defines the covariance structure for regression errors in the standard regression equation $\boldsymbol{Y} = \boldsymbol{XB} + \boldsymbol{E}$. For univariate designs, this matrix will be 1×1 and contain the estimated variance of the error term. More complex structures, such as compound symmetry or auto-regressive structures, may be required for multivariate or repeated measures designs. These structures allow you to describe the variance between measures on the same subject.

Enter estimates of the variance of each group on the matrix diagonal. Enter estimates of the covariance between measurements on the same subject on the off diagonals.

When you have completed the matrix, click to proceed.

4.5.2 Outcomes Covariance (if solving for a single Gaussian covariate)

Enter the variance of the response variable(s).

When finished entering your values, click to proceed.

4.5.3 Variance of Covariate (if solving for a single Gaussian covariate)

Enter the variance of the covariate.

When finished entering your values, click to proceed.

4.5.4 Covariance of Outcomes and Covariate (if solving for a single Gaussian covariate)

When controlling for a Gaussian covariate, power is typically improved when the covariate explains some portion of the variance in the outcome. The covariance matrix between the outcomes and the Gaussian covariate, Σ_{YG}, describes the association between the outcomes and the Gaussian covariate.

In the matrix provided, enter values for the covariance between the outcome(s) and the Gaussian covariate.* For univariate designs, the matrix is 1×1 and contains only the covariance between the outcome and the Gaussian covariate. For multivariate and repeated measures designs, the matrix is $p \times 1$, where p is the number of outcomes. Each row contains the covariance between the Gaussian covariate and the corresponding outcome.

When you have completed the matrix, click to proceed.

*Note that the dimensions of the matrix are pre-determined.

4.5.5 Sigma Scale Factors

GLIMMPSE allows users to specify scale factors for the covariance matrices. For the General Linear Multivariate Model with Fixed Predictors, the scale factors are applied to the user-specified $\boldsymbol{\Sigma}_{\boldsymbol{E}}$ matrix. For the General Linear Multivariate Model with Fixed Predictors and a Gaussian Predictor, the scale factors are applied to the $\boldsymbol{\Sigma}_{\boldsymbol{E}}$ matrix, which is calculated from $\boldsymbol{\Sigma}_{\boldsymbol{Y}}, \boldsymbol{\Sigma}_{\boldsymbol{G}},$ and $\boldsymbol{\Sigma}_{\boldsymbol{YG}}$.

To specify one or more scale factors for your $\boldsymbol{\Sigma}_{\boldsymbol{E}}$ matrix, enter the scale factors in the Σ_E *Matrix Scale Factors* box. After each entry, click Add, press Enter on your keyboard, or click anywhere on the screen. To delete a value, select the unwanted value and click Delete to remove the value from the list.

When finished entering your values, click to proceed.

4.6 Options

4.6.1 Statistical Tests

On the options screens, select the statistical tests you want to use and specify how you want results displayed.

Statistical Tests

For the General Linear Multivariate Model with Fixed Predictors, you may select any combination of the UNIREP, Hotelling-Lawley Trace, Pillai-Bartlett Trace, or Wilk's Lambda tests to include in the power or sample size calculations. For the General Linear Multivariate

Model with Fixed Predictors and a Gaussian Predictor, only the UNIREP or Hotelling-Lawley Trace may be selected, since theory is not currently available for the Pillai-Bartlett Trace or the Wilk's lambda.*

Check the appropriate boxes to select the statistical tests you would like to include in your calculations.

When your selections are complete, click to proceed.

*Note: Only the Hotelling-Lawley and Univariate Approach to Repeated Measures are valid when controlling for a Gaussian covariate.

4.6.2 Power Method

For the General Linear Multivariate Model with Fixed Predictors and a Gaussian Predictor, the user must indicate whether unconditional and/or quantile power should be used.

If you select quantile power, you must enter the desired quantities.

When your selections are complete, click to proceed.

4.6.3 Confidence Intervals

This screen allows you to remove confidence intervals for power. If you would not like to include confidence intervals for power, click the check box.

When your selection is complete, click to proceed.

4.6.4 Power Curve

If desired, this screen allows the user to specify the dimensions of a power curve. For the power curve the Y-axis on the graph always represents power, but users may select whether the X-axis represents total sample size, the $\boldsymbol{B}$ scale factor, or the $\boldsymbol{\Sigma}_{\boldsymbol{E}}$ scale factor.

When your selections are complete, click to proceed.

4.7 Calculate

Click Calculate to receive the results of your power analysis.

For detailed information regarding the Results Report, refer to section 2.3.4 above.