

This document contains screenshots for the sample size analysis for Homework 2.

- Click the “New Study” button to start a new power and sample size analysis.
- or
- Click the “Upload” button to upload a json file with a previous study design that you have saved.

◆ GLIMMPSE

General Linear Mixed Model Power and Sample Size

Design a Study

Welcome to GLIMMPSE. The GLIMMPSE software calculates power and sample size for study designs with normally distributed outcomes. Select one of the options below to begin a power or sample size calculation.

New Study

Start a new design.

Upload



You have previously used GLIMMPSE and wish to work on a saved design.

For a new study: Add title here

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General Linear Mixed Model Power and Sample Size

Untitled Study: Study title

Progress  Help  Save  Home 

Please pick a concise title for the study:



Click the “Power” or “Sample Size” button depending on what you want to solve for. In this case, we are solving for sample size.

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General Linear Mixed Model Power and Sample Size

module2: Solve for

Progress  Help  Save  Home 

Please indicate whether you would like to solve for power or total sample size.

If you have a rough idea of the number of research participants you will be able to recruit, then solve for power.

If you have few restrictions on recruitment then you may wish to solve for sample size.

Power

Sample Size



On the “Target Power” screen, we indicate that we want power values of 0.85, 0.90 and 0.95. Type each desired power value and hit enter after each.

Please choose one or more power values, for which you wish to calculate minimum sample size.

All target power values must be between 0 and 1, exclusive.

Target Power	remove
0.85	
0.9	
0.95	


You can specify multiple values of interest in the same GLIMMPSE study design.

We now move to select the hypothesis test of interest. Thus, we click the Hotelling-Lawley trace.

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module2: Statistical tests

Progress  Help  Save  Home 

Please choose one or more statistical tests. If you are unsure which to pick, we recommend the Hotelling Lawley Trace test due to its equivalence to a mixed model test.

- Hotelling Lawley Trace
- Pillai-Bartlett Trace
- Wilks Likelihood Ratio
- Box Corrected
- Geisser-Greenhouse Corrected
- Huynh-Feldt Corrected
- Uncorrected



Now we choose the Type I error rate.

We type in 0.05 and then we click the plus sign to add this value to the design.

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module2: Type I error rates Progress Help Save Home

A Type I error occurs when a scientist declares a difference when none is present in the population. The Type I error rate is the probability of that kind of error, a false positive, and is often referred to as α (alpha). A Type I error rate can range from 0 to 1. Although the most commonly used value is 0.05, we recommend 0.01.

Type I Error Rate	remove
0.05	<input type="button" value="x"/>

Enter outcome variables here.

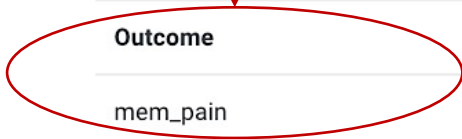
Then, click the plus sign to add the outcome entered to the design.

Enter the name of each outcome variable one at a time in the underlined space below. For example, in a study investigating cholesterol-lowering medication, the outcome variables could be HDL, LDL, and total cholesterol.

Note that repeated measurement information will be addressed on the next screen.





Please name the one or more outcomes.

<input type="text"/>	
Outcome	remove
<input type="text" value="mem_pain"/>	



This is a longitudinal study with three repeated measurements of the response variable.

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module2: Repeated measures Progress  Help  Save  Home 

GLIMMPSE allows you to define within-participant factors, specified as repeated measures. An independent sampling unit provides one or more observations such that observations from one unit are statistically independent from any other distinct unit while observations from the same unit may be correlated. Repeated measures are present when a response variable is measured on each independent sampling unit on two or more occasions or under two or more conditions. The values of the repeated measures (that is, the levels of the within-participant factors) distinguish the occasions or conditions.

If the study includes repeated measures, click "Add Repeated Measure" and follow the prompts.

You may specify up to 5 repeated measures. Each repeated measure you add will apply to each outcome you specified on the previous page.

[Define Repeated Measure](#)



Here, we have named the dimension as time.

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General Linear Mixed Model Power and Sample Size

module2: Repeated measures

Progress  Help  Save  Home 

What is the name of the dimension you will be measuring?

The text entered in the "Dimension" text box indicates the dimension over which measures were taken (e.g. time, days, locations, etc.). The choice of "Type" indicates whether the repeated measures are numeric (e.g. time), or categorical (e.g. arm, leg, hand).

Dimension:

time

Cancel

Next: Type

Here, we define the type of data that our dimension “time” represents

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General Linear Mixed Model Power and Sample Size

module2: Repeated measures

Progress  Help  Save  Home 

What type of data is time?

Categorical

Numeric

Cancel

Back

Next: No. Measurements

Enter the number of repeated measurements of the response variable.

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General Linear Mixed Model Power and Sample Size

module2: Repeated measures

Progress  Help  Save  Home 

Number of measurements of time?

3

You must have between 2 and 10 repeats (inclusive)

Cancel

Back





Next: Spacing

Here, we enter the spacing values

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General Linear Mixed Model Power and Sample Size

module2: Repeated measures

Progress  Help  Save  Home 

Spacing

If the repeated measures are numeric, the spacing values must be unique nonnegative integers, in ascending order.

Set values myself

Select values by series

Measurement #1 at

1

Measurement #2 at

2

Measurement #3 at

3

Cancel

Back

Update repeated measure

This screen shows a summary of the information entered for the repeated measures. Additional note: GLIMMPSE can measure a given response variable up to 10 times.





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If the study includes repeated measures, click "Add Repeated Measure" and follow the prompts.

You may specify up to 5 repeated measures. Each repeated measure you add will apply to each outcome you specified on the previous page.

Define Repeated Measure

Repeated Measure Dimension	Type	Measurements	Edit	Remove
time	Numeric	["1", "2", "3"]		

Here, there is no clustering, so we leave the clustering screen blank, and move on to the “Define Fixed Predictor” screen.

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module2: Clustering

Progress  Help  Save  Home 



An independent sampling unit provides one or more observations such that observations from one unit are statistically independent from any other distinct unit while observations from the same unit may be correlated.

In a clustered design, the independent sampling unit is a cluster, such as a community, school, or classroom. Observations within a cluster are correlated. The labels for observations within a cluster must be exchangeable. For example, child "ID" within classroom can be reassigned arbitrarily. In contrast, observations across time cannot be reassigned and should not be considered clustered observations. The common correlation between any pair of cluster members is termed the intraclass correlation or intracluster correlation.

To include clustering in the study, click "Add Clustering" and follow the prompts.

You may specify up to 10 levels of clustering.

Add Clustering



Here, we define the fixed predictor.

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module2: Fixed predictors

Progress  Help  Save  Home 

Each independent sampling unit has one or more observations which are statistically independent from observations from any other unit.

GLIMMPSE allows you to define fixed predictors which divide the independent sampling unit into groups. One common example of a fixed predictor is treatment, with values placebo and drug, for which the independent sampling unit is randomized to a placebo group or a drug group. Another is gender, with values male or female.

If the design has no fixed predictors, do not define any here.

Define Fixed Predictor



Now type in Treatment and hit enter. Remember, predictor variables are the same thing as between-ISU factors.

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General Linear Mixed Model Power and Sample Size

module2: Fixed predictors

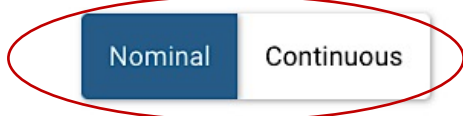
Progress  Help  Save  Home 

Please name the
predictor:

treat

Cancel **Next: Data Type**

Here, we define what type of data and move on to define the groups.



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module2: Fixed predictors

Progress ○ Help ? Save ↓ Home 🏠

What type of data is treat?

Nominal Continuous



Cancel Back: Data Type Next: Groups

Here, we define the groups.


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General Linear Mixed Model Power and Sample Size


module2: Fixed predictors


Progress  Help  Save  Home 

Please name at
least two groups:

Groups:

 treat_group

 control

Cancel Back: Type Update predictor

An interaction hypothesis is what we have described in lecture as a between-by-within independent sampling unit hypothesis. Interaction hypotheses allow us to ask questions about the effect of two or more factors or variables. In longitudinal studies, the interaction hypothesis of interest is frequently a time-by-predictor interaction, such as time-by-treatment or time-by-intervention. Click the treatment by time interaction.

Each power or sample size calculation is based on selecting a specific study hypothesis. The options below show the hypotheses which are available for the current study design. Specify the hypothesis that represents your scientific question.

GLIMMPSE chooses sensible contrast matrices based on cell means coding. Should you wish to define your own contrast matrices, pick the highest order interaction and choose from the advanced options in the hypothesis components.

Select a hypothesis from the list.

Effects Available for Consideration	Nature of Variation
<input checked="" type="radio"/> treat x time: Interaction	Between x Within
<input type="radio"/> time: Main Effect	Within
<input type="radio"/> treat: Main Effect	Between
<input type="radio"/> Grand Mean	Between

Specify means for:

Factors in Hypothesis All Factors



In this example, "All mean differences zero" was selected to indicate the type of contrast desired.

What type of contrast do you wish among the means defined by your groups and repeated measures?

All mean differences zero

A parameter is a characteristic of a population. The parameters of interest are differences between groups at individual repeated measures.

The null hypothesis is that all pairwise differences between groups are the same among all pairs of repeated measures.

Show Advanced Options



This screen gives you the option to select a value different than zero for the contrast comparison constant.

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module2: Theta 0

Progress  Help  Save  Home 



A hypothesis compares parameters to a constant, the contrast comparison constant, θ_0 . This is almost always zero. If you choose a value other than zero, be sure that you understand that the hypothesis you define is scientifically meaningful. Also note that the description and interpretation of your hypothesis given when choosing your contrasts will be affected.



The next screen allows one to specify relative group sizes. Here, study participants are equally randomized to the two levels of treatment: sensory focus (treat) and standard of care (control). Thus, we leave the screen as follows.

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General Linear Mixed Model Power and Sample Size

module2: Group size ratios

Progress  Help  Save  Home 

For equal group sizes, input a "1" in the block next to each group. This is the default study design.

For unequal group sizes, specify the ratio of the group sizes. For example, consider a design with an active drug group and a placebo group. If twice as many study participants receive the placebo, a value of "2" would be selected for the placebo group, and a value of "1" would be selected for the active drug group.

Group size ratios

treat	treat_group	1
	control	1



Enter the mean values for the outcome variable within each group as shown below.

GLIMMPSE

General Linear Mixed Model Power and Sample Size

week2_nv: Marginal means

Progress  Help  Save  Home 

The table below shows the mean values for outcome **mem_pain** within each group in the study. Each group is represented by a row in the table, and each repeated measure dimension is represented by a column.

Enter the mean values you expect to observe for outcome **mem_pain** within each group. The table should contain at least one value that is non-zero. Also, at least two groups should have means which differ by a scientifically meaningful amount.

Expected mean values, per group, for *mem_pain*

		time		
		1	2	3
treat	treat_group	3.6	2.8	0.9
	control	4.5	4.3	3

Set blank values to

value



Often, in sample size analysis, it is useful to consider mean differences larger or smaller than our initial guess. Here, the initial guess is well supported by the literature review, so we type in 1 on the next screen, to indicate that our initial guess is the right size. The Scale Factors option in GLIMMPSE is one way of 'Accounting for Uncertainty' within GLIMMPSE.

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General Linear Mixed Model Power and Sample Size

module2: Scale factor for the marginal means

Progress  Help  Save  Home 

In power analysis, it is not possible to know the exact values of means before the experiment is observed. Scale factors allow you to consider alternative values for the means by scaling the values entered on the previous screen.
For example, entering the scale factors 0.5, 1, and 2 would compute power for the mean values divided by 2, the mean values as entered, and the mean values multiplied by 2.

Enter a scale factor:

number > 0 

Scale Factor

1

remove





Enter the standard deviation as shown. We discussed variance in the lecture. Standard deviation is simply the square root of variance.

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General Linear Mixed Model Power and Sample Size

module2: Variability across outcomes

Progress  Help  Save  Home 

Enter the standard deviation you expect to observe for each outcome.

Outcome	Standard Deviation
mem_pain	0.9



Enter the ratios of standard deviations for time.

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General Linear Mixed Model Power and Sample Size

module2: Repeated measure standard deviation ratios

Progress  Help  Save  Home 

Define the ratios of standard deviations for time. One of your values should be 1 and the others should represent the ratio of that value to that value:

For example, if you believe that the standard deviation doubles at each time, enter the values 1, 2, 4, 8... etc.

<u>time</u>	<u>Standard Deviation Ratio</u>
1	1
2	1
3	1



Enter the correlations you expect to observe as shown below.

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General Linear Mixed Model Power and Sample Size

module2: Repeated measure correlation

Progress  Help  Save  Home 

For a given research participant, responses vary across outcomes and across repeated measurements. The amount of variability can dramatically impact power and sample size.

Define the **time** correlation matrix, by entering correlations you expect to observe among the chosen spacing values of **time**:

Unstructured LEAR

time

	1	2	3
1	1	0.5	0.406
2	0.5	1	0.5
3	0.406	0.5	1

(each off-diagonal correlation must be between -1 and 1, exclusive)



Again, because we have good evidence from the literature review for the variability and correlation, we enter 1 for the scale factor as shown below.

GLIMMPSE

General Linear Mixed Model Power and Sample Size

module2: Scale factor variance

Progress  Help  Save  Home 

Changes in variability can dramatically affect power and sample size results. It is not possible to know the variability until the experiment is observed. Scale factors allow you to consider alternative values for variability by scaling the calculated covariance matrix. For example, entering the scale factors 0.5, 1, and 2 would compute power for the covariance matrix divided by 2, the covariance matrix as entered, and the covariance matrix multiplied by 2.

You may add up to 10 scale factors.

Choose a number greater than zero



Scale Factor

remove

1



When we hit the “Calculate” button, the results are shown in the power results table.

Calculate

Download result

Results Matrices Design

Design



Hypothesis



Design Dimensions



Parameters



Optional Specifications



We can save results and study design inputs by using the “Save” button.

GLIMMPSE

General Linear Mixed Model Power and Sample Size

module2: Calculate

Progress  Help  Save  Home 

Calculate

Download result

Results Matrices Design

Power	Total Sample Size	Target Power	Means Scale Factor	Variability Scale Factor	Test	Power Method	Type I Error Rate
0.869	34	0.85	1	1	Hotelling Lawley Trace	conditional	0.05
0.909	38	0.9	1	1	Hotelling Lawley Trace	conditional	0.05
0.957	46	0.95	1	1	Hotelling Lawley Trace	conditional	0.05

Note: We were trying to find a sample size large enough so that we had power values of 0.85, 0.9, and 0.95. Those numbers are shown as “Target Power.” They are called “Target Power” because that is what we were aiming for. You can see that we got power values slightly larger than the target values. In fact, the power values are 0.869, 0.909 and 0.957. The reason that the actual values are slightly larger is because sample size is discrete. This is because we can’t recruit a half or a third of a person. In addition, we need to have an even sample size, since we have equal randomization into two groups.

In case you are interested, here are the matrices that were used for the calculation.

Results **Matrices** Design

$$Es(\mathbf{X}) = \begin{bmatrix} 1.00 & 0.00 \\ 0.00 & 1.00 \end{bmatrix}$$

$$\mathbf{B} = \begin{bmatrix} 3.60 & 2.80 & 0.900 \\ 4.50 & 4.30 & 3.00 \end{bmatrix}$$

$$\mathbf{C} = [1.00 \quad -1.00]$$

$$\mathbf{U} = \begin{bmatrix} 1.00 & 1.00 \\ -1.00 & 0.00 \\ 0.00 & -1.00 \end{bmatrix}$$

$$\Sigma_* = (\mathbf{U}'_o \Sigma_o \mathbf{U}_o) \otimes (\mathbf{U}'_r \Sigma_r \mathbf{U}_r) \otimes (\mathbf{U}'_c \Sigma_c \mathbf{U}_c)$$

$$= [0.810] \otimes \begin{bmatrix} 1.00 & 0.594 \\ 0.594 & 1.19 \end{bmatrix} \otimes [1.00] = \begin{bmatrix} 0.810 & 0.481 \\ 0.481 & 0.962 \end{bmatrix}$$

$$\Theta_0 = [0.00 \quad 0.00]$$

$$\alpha = 0.05$$

$$\Theta = [0.600 \quad 1.20]$$

$$\mathbf{M} = [2.00]$$

$$\nu_e = 2$$

No. of replicated rows in design matrix: 1

$$Es(\Delta) = \begin{bmatrix} 0.180 & 0.360 \\ 0.360 & 0.720 \end{bmatrix}$$

For notation details, please see

1. Glueck DH, Muller KE. Adjusting power for a baseline covariate in linear models. *Statistics in Medicine*. 2003;22:2535-2551.
2. Muller KE, Stewart PW. *Linear Model Theory: Univariate, Multivariate, and Mixed Models*. Hoboken, NJ: Wiley; 2006.