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| **GLIMMPSE: Power Service REST API** |

Contents

[**GLIMMPSE: Power Service REST API** 1](#_Toc292959417)

[1 Introduction 2](#_Toc292959418)

[2 The Power Service 2](#_Toc292959419)

[3 Parameters for the General Linear Multivariate Model 2](#_Toc292959420)

[3.1 Matrix Inputs 4](#_Toc292959421)

[3.1.1 Basic Matrices 4](#_Toc292959422)

[3.1.2 Fixed / Random Matrices 4](#_Toc292959423)

[3.1.3 Required Matrices 5](#_Toc292959424)

[3.1.4 Matrix Dimensions 8](#_Toc292959425)

[3.2 List Inputs 8](#_Toc292959426)

[3.2.1 Test List 8](#_Toc292959427)

[3.2.2 Power List 9](#_Toc292959428)

[3.2.3 Alpha List 9](#_Toc292959429)

[3.2.4 Per Group Sample Size List 9](#_Toc292959430)

[3.2.5 Beta Scale List 10](#_Toc292959431)

[3.2.6 Sigma Scale List 10](#_Toc292959432)

[3.2.7 Power Method List 10](#_Toc292959433)

[3.2.8 Quantile List 10](#_Toc292959434)

[4 The REST API 11](#_Toc292959435)

[4.1 Calculating Power 11](#_Toc292959436)

[4.2 Calculating Sample Size 12](#_Toc292959437)

[4.3 Calculating Detectable Difference 12](#_Toc292959438)

[5 Examples 13](#_Toc292959439)

[5.1 One-Sample T-Test 13](#_Toc292959440)

[5.2 One-Way ANOVA 14](#_Toc292959441)

# Introduction

The GLIMMPSE software system provides a web based user interface to estimate power and sample size for the general linear multivariate model (GLMM) with or without a baseline covariate. The GLIMMPSE system consists of five main components:

* Glimmpse.com user interface - a Javascript/GWT front-end user interface
* **Power Service** - Java web service which processes power/sample size requests
* Chart Service - Java web service which produces graphs. For the Glimmpse system, this service produces power curves.
* File Service - Java web service providing upload/save functionality for study design information
* JavaStatistics library - low level library containing routines for computing GLMM power

This document describes the REST API for the Power Service, version 1.0.0. It assumes basic familiarity with [HTTP](http://www.w3.org/Protocols/), [REST](http://www.ics.uci.edu/%7Efielding/pubs/dissertation/top.htm), and the GLMM. For additional background on GLMM power calculations when controlling for a baseline covariate, please see Glueck and Muller1.

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# The Power Service

The Power Service component of the GLIMMPSE system is a Java web service which processes requests for power and sample size for the GLMM. The system supports GLMM study designs with either all fixed predictors (GLMM(F)), or fixed predictors with a single baseline covariate (GLMM(F,g)). The REST API allows users to specify the matrices required for GLMM power calculations, and request power, sample size, or minimum detectable difference. Users may request a list of power results which can then be displayed in tables or as power curves.

The system is implemented using the [Restlet Framework](http://www.restlet.org/). Requests to the power service are received via an AJAX call from the Glimmpse user interface, and data is encoded as XML. For version 1.0.0, power/sample size results are not persistent, so the service deviates slightly from the standard definition of create/update/delete in the REST philosophy.

The Power Service was developed and tested for use within the [Apache Tomcat Server (v 6.0)](http://tomcat.apache.org/).

# Parameters for the General Linear Multivariate Model

Power calculations for the GLMM are based on several matrices which describe the study design, estimated regression coefficients, estimated variability, and study hypotheses. Users may request multiple power values in a single request to the power service, including variations such as different statistical tests, type I error values, sample sizes, desired power values, and scale factors for regression coefficients and variability. For GLMM(F,g) designs, multiple power methods and quantiles may be specified.

All requests to the power service must specify GLMM power parameters with the general form (attributes within [] characters may be optional depending on the request) :

<glmmPowerParameters [seed=*’seedValue*’]>

<testList><v>*(hlt|wl|pbt|unirep|unirepBox|unirepGG|unirepHF)*</v>...

<v>*(hlt|wl|pbt|unirep|unirepBox|unirepGG|unirepHF)*</v></testList>

<alphaList><v>*alpha*</v>...<v>*alpha*</v></alphaList>

<sigmaScaleList><v>*sigmaScale*</v>...<v>*sigmaScale*</v></sigmaScaleList>

[<powerList><v>*power*</v>...<v>*power*</v></powerList>]

[<sampleSizeList><v>*sampleSize*</v>...<v>*sampleSize*</v></sampleSizeList>]

<betaScaleList><v>*betaScale*</v>...<v>*betaScale*</v></betaScaleList>

<powerMethodList><v>*(conditional|quantile|unconditional)*</v>...

<v>*(conditional|quantile|unconditional)*</v></powerMethodList>

<quantileList><v>*quantile*</v>...<v>*quantile*</v></quantileList>

<matrix name='*design*' rows='*n*' columns='*q*'>

<r><c>*d1,1*</c><c>*d1,2*</c>...<c>*d1,q*</c></r>

...

<r><c>*dn,1*</c><c>*dn,2*</c>...<c>*dn,q*</c></r>

</matrix>

<fixedRandomMatrix name='betweenSubjectContrast' combineHorizontal='true' >

<matrix name='*fixed*' rows='*a*' columns='*q*'>

<r><c>*d1,1*</c><c>*d1,2*</c>...<c>*d1,q*</c></r>

...

<r><c>*da,1*</c><c>*da,2*</c>...<c>*da,q*</c></r>

</matrix>

<matrix name='*random*' rows='*a*' columns='*1*'>

<r><c>*d1,1*</c></r>

...

<r><c>*da,1*</c></r>

</matrix>

</fixedRandomMatrix>

<matrix name='*withinSubjectContrast*' rows='*p*' columns='*b*'>

<r><c>*d1,1*</c><c>*d1,2*</c>...<c>*d1,b*</c></r>

...

<r><c>*dp,1*</c><c>*dp,2*</c>...<c>*dp,b*</c></r>

</matrix>

<matrix name='*theta*' rows='*a*' columns='*b*'>

<r><c>*d1,1*</c><c>*d1,2*</c>...<c>*d1,b*</c></r>

...

<r><c>*da,1*</c><c>*da,2*</c>...<c>*da,b*</c></r>

</matrix>

<fixedRandomMatrix name='beta' combineHorizontal='true' >

<matrix name='*fixed*' rows='*q*' columns='*p*'>

<r><c>*d1,1*</c><c>*d1,2*</c>...<c>*d1,p*</c></r>

...

<r><c>*dq,1*</c><c>*dq,2*</c>...<c>*dq,p*</c></r>

</matrix>

<matrix name='*random*' rows='*1*' columns='*p*'>

<r><c>*d1,1*</c><c>*d1,2*</c>...<c>*d1,p*</c></r>

</matrix>

</fixedRandomMatrix>

<!-- Specify sigmaError if all fixed predictors -->

<matrix name='*sigmaError*' rows='*p*' columns='*p*'>

<r><c>*d1,1*</c><c>*d1,2*</c>...<c>*d1,p*</c></r>

...

<r><c>*dp,1*</c><c>*dn,2*</c>...<c>*dp,p*</c></r>

</matrix>

<!-- Specify the following three sigma matrices if controlling for a baseline covariate -->

<matrix name='*sigmaGaussianRandom*' rows='*1*' columns='*1*'>

<r><c>*d1,1*</c></r>

</matrix>

<matrix name='*sigmaOutcome*' rows='*p*' columns='*p*'>

<r><c>*d1,1*</c><c>*d1,2*</c>...<c>*d1,p*</c></r>

...

<r><c>*dp,1*</c><c>*dn,2*</c>...<c>*dp,p*</c></r>

</matrix>

<matrix name='*sigmaOutcomeGaussianRandom*' rows='*p*' columns='*1*'>

<r><c>*d1,1*</c></r>

...

<r><c>*dp,1*</c></r>

</matrix>

</glmmPowerParameters>

The glmmPowerParameters tag takes a single optional attribute specifying the random seed used in simulation requests. The matrix and list input parameters are described in sections 2.1 and 2.2

## Matrix Inputs

The power service supports two types of matrix inputs:

* Basic Matrix - a simple *r x c* matrix
* Fixed / Random Matrix - a matrix which has both a fixed submatrix and a random submatrix

### Basic Matrices

A basic matrix is a 2-dimensional array of real numbers with *r* rows and *c* columns. The XML format for specifying a basic matrix for the Power Service is:

<matrix name='*name*' rows='*r*' columns='*c*'>

<r><c>*d1,1*</c><c>*d1,2*</c>...<c>*d1,c*</c></r>

...

<r><c>*dr,1*</c><c>*dn,2*</c>...<c>*dr,c*</c></r>

</matrix>

|  |  |  |
| --- | --- | --- |
| **Variable** | **Type** | **Description** |
| name | String | The name of the matrix. |
| rows | Integer | Number of rows in the matrix |
| columns | Integer | Number of columns in the matrix |
| di,j | Real | Value of cell i,j in the matrix |

### Fixed / Random Matrices

A fixed random matrix is a 2-dimensional array of real numbers, which is separated into both a fixed submatrix and a random submatrix. Both the regression coefficient matrix (β) and the between subject contrast matrix (C) are represented as fixed/random matrices. These matrices will have both fixed and random components for GLMM(F,g) designs. The XML format for a fixed/random matrix is:

<fixedRandomMatrix name='*name*' combineHorizontal='[true|false]' >

<matrix name='*fixed*' rows='*r*' columns='*c*'>

<r><c>*d1,1*</c><c>*d1,2*</c>...<c>*d1,c*</c></r>

...

<r><c>*dr,1*</c><c>*dn,2*</c>...<c>*dr,c*</c></r>

</matrix>

<matrix name='*random*' rows='*s*' columns='*d*'>

<r><c>*d1,1*</c><c>*d1,2*</c>...<c>*d1,d*</c></r>

...

<r><c>*ds,1*</c><c>*dq,2*</c>...<c>*ds,d*</c></r>

</matrix>

</fixedRandomMatrix>

The fixedRandomMatrix tag has two attributes:

|  |  |  |
| --- | --- | --- |
| **Variable** | **Type** | **Description** |
| name | String | the name of the matrix |
| combineHorizontal | Boolean | Indicates if the complete matrix should be created by combining the fixed and random submatrices vertically or horizontally |

In addition, the fixedRandomMatrix tag encloses two basic matrices, named "fixed" and "random", which specify the data in the fixed and random submatrices.

### Required Matrices

This section describes the individual matrices that must be specified for a power or sample size calculation.

#### The Design Essence Matrix

The fixed portion of the study design matrix should be specified as a basic matrix with name “design”. There are no restrictions on the coding scheme, although the design matrix should be full rank. The design matrix represents the study design for fixed predictors. Please see Muller and Stewart2 for more details.

#### The Between Subject Contrast Matrix

A single between subject contrast matrix must be specified. The between subject contrast matrix ("C" matrix) defines the between subject hypotheses that the user wishes to test. When controlling for a baseline covariate, this matrix includes a random column vector with the same number of rows as the contrast matrix. It is most common to have 0's in this column - since the value of the baseline covariate is expected to differ across subjects, between subject hypotheses do not typically involve the baseline covariate.

<fixedRandomMatrix name='betweenSubjectContrast' combineHorizontal='true' >

<matrix name='*fixed*' rows='*a*' columns='*q*'>

<r><c>*d1,1*</c><c>*d1,2*</c>...<c>*d1,q*</c></r>

...

<r><c>*da,1*</c><c>*da,2*</c>...<c>*da,q*</c></r>

</matrix>

<matrix name='*random*' rows='*a*' columns='*1*'>

<r><c>*d1,1*</c></r>

...

<r><c>*da,1*</c></r>

</matrix>

</fixedRandomMatrix>

#### The Within Subject Contrast Matrix

The within subject contrast ("U" matrix) defines hypotheses on responses within the same subject (or other sampling unit).

<matrix name='*withinSubjectContrast*' rows='*p*' columns='*b*'>

<r><c>*d1,1*</c><c>*d1,2*</c>...<c>*d1,b*</c></r>

...

<r><c>*dp,1*</c><c>*dp,2*</c>...<c>*dp,b*</c></r>

</matrix>

#### The Theta Null Matrix

A single theta null matrix must be specified. The theta null matrix represents the null hypotheses for the contrasts defined in the C and U matrices. It is most common to have 0's in all cells of this matrix, although this depends on the specific hypotheses being tested.

<matrix name='*theta*' rows='*a*' columns='*b*'>

<r><c>*d1,1*</c><c>*d1,2*</c>...<c>*d1,b*</c></r>

...

<r><c>*da,1*</c><c>*da,2*</c>...<c>*da,b*</c></r>

</matrix>

#### The Beta Matrix

A single beta matrix must be specified. This represents the estimated regression coefficients for the model (the interpretation depends on the design matrix coding scheme used). If the study design includes a baseline covariate, this matrix will include an additional "random" row to represent the estimated coefficients for the baseline covariate. The values in this row will be automatically generated based on the covariance matrices described below, and should simply be filled with 1's.

<fixedRandomMatrix name='beta' combineHorizontal='true' >

<matrix name='*fixed*' rows='*q*' columns='*p*'>

<r><c>*d1,1*</c><c>*d1,2*</c>...<c>*d1,p*</c></r>

...

<r><c>*dq,1*</c><c>*dq,2*</c>...<c>*dq,p*</c></r>

</matrix>

<matrix name='*random*' rows='*1*' columns='*p*'>

<r><c>1</c><c>1</c>...<c>1</c></r>

</matrix>

</fixedRandomMatrix>

#### The Covariance (Σ) Matrices

The sigma matrices represent the estimated covariance for the model. Different matrices are specified for fixed designs as opposed to those with a Gaussian covariate. In general, all sigma matrices should be symmetric and positive definite. All cell values along the diagonal must be positive real numbers. Off diagonal values should be real numbers.

##### Covariance in GLMM(F) Designs

When the study design contains only fixed predictors, a single "sigmaError" matrix is specified. This matrix represents the estimated residual (or "error") covariance. For univariate study designs, this will be a 1x1 scalar value.

<matrix name='*sigmaError*' rows='*p*' columns='*p*'>

<r><c>*d1,1*</c><c>*d1,2*</c>...<c>*d1,p*</c></r>

...

<r><c>*dp,1*</c><c>*dn,2*</c>...<c>*dp,p*</c></r>

</matrix>

##### Covariance in GLMM(F,g)

For study designs including a baseline covariate, three matrices must be specified to fully describe the variability.

Covariance of Baseline Covariate (ΣG)

Since only a single baseline covariate is allowed, this matrix is 1x1 and represents the estimated variance of the baseline covariate.

Covariance of Responses (ΣY)

This matrix defines the covariance between responses on the same subject (or sampling unit). For univariate designs, this is a 1x1 matrix.

<matrix name='*sigmaOutcome*' rows='*p*' columns='*p*'>

<r><c>*d1,1*</c><c>*d1,2*</c>...<c>*d1,p*</c></r>

...

<r><c>*dp,1*</c><c>*dn,2*</c>...<c>*dp,p*</c></r>

</matrix>

Covariance of Outcomes with Baseline Covariate (ΣYG)

This matrix is a column vector indicating the covariance between each outcome and the baseline covariate.

<matrix name='*sigmaOutcomeGaussianRandom*' rows='*p*' columns='*1*'>

<r><c>*d1,1*</c></r>

...

<r><c>*dp,1*</c></r>

</matrix>

### Matrix Dimensions

For successful computation of power for the GLMM, the required matrices must conform appropriately to one another. The following table lists the dimensions required for each of the matrices:

|  |  |  |  |
| --- | --- | --- | --- |
| **Matrix** | **Rows** | **Columns** | **Conformance Details** |
| X: Design essence matrix | N | Q | Columns equal number of rows in β |
| C: Between subject contrast | A | Q | Columns equal number of rows in β  Rows must be one less than number of rows in X |
| U: Within subject contrast | P | B | Rows equals the number of columns in β |
| Θ: Null hypothesis values | A | B | Rows equals the number of rows in C Columns equals the number of columns in U |
| β: Regression coefficient estimates | Q | P | Rows equals the number of columns in X (number of predictors) Columns equals the number of columns in U (number of outcomes) |
| **GLMM(F) Designs** | | | |
| Σerror: covariance matrix of residuals | P | P | Matrix is square and symmetric. Rows/columns equal the number of columns in β |
| **GLMM(F,g) Designs** | | | |
| ΣG: Covariance of Gaussian predictor | 1 | 1 | Since only a single baseline covariate is allowed, this matrix is 1x1. |
| ΣYG: Covariance of Gaussian predictor with outcomes | P | 1 | Rows equals the number of columns in β |
| ΣY: Covariance of outcomes | P | P | Rows/columns equal the number of columns in β (i.e. number of outcomes) |

## List Inputs

Once the required matrices are specified, users may request a list of powers by varying the basic study design. Users can scale the regression coefficients in the beta matrix and the variability specified in the sigma matrix. Users may also specify several statistical tests, power methods (for designs with a baseline covariate), power values, alpha levels, and per group sample size values.

Note that each combination of values specified in these lists will produce a single power calculation. Therefore, list sizes should be minimized to avoid long processing times.

### Test List

The test list includes all statistical tests to be run. It is required for all requests. The test list is specified as:

<testList><v>*testList*</v>...<v>*testList*</v></testList>

Power values should be equivalent for univariate designs regardless of the test selected. However, no uniformly most powerful test exists for the multivariate linear model. The following tests are supported:

* unirep - Univariate approach to repeated measures (uncorrected)
* unirepBox - Univariate approach to repeated measures with Box correction
* unirepGG - Univariate approach to repeated measures with Geisser-Greenhouse correction
* unirepHF - Univariate approach to repeated measures with Huynh-Feldt correction
* wl - Wilks' Lambda
* hlt - Hotelling-Lawley trace
* pbt - Pillai-Bartlett trace

### Power List

The power list includes all desired power values. It is valid for sample size or detectable difference requests (it is ignored for power requests). A power list is specified as follows:

<powerList><v>*power*</v>...<v>*power*</v></powerList>

where each listed *power* is a decimal between 0 and 1. Researchers typically require a minimum of 80% power (0.80), so values between 0.80 and 1 are most common.

### Alpha List

The alpha list specifies various type I error rates. It is required for all requests.

<alphaList><v>*alpha*</v>...<v>*alpha*</v></alphaList>

where each listed *alpha* is a decimal between 0 and 1. The most commonly used values are 0.01, 0.05, and 0.10, which correspond to confidence levels of 99%, 95%, and 90% respectively.

### Per Group Sample Size List

The per group sample size list includes all desired group sample sizes. It is valid for power or detectable difference requests (it is ignored for sample size requests). The total sample size for the power calculation is determined by multiplying the per group size by the number of rows in the design matrix.

For example, consider the following design matrix for a one-way ANOVA with 3 groups:

For a per group sample size of 25, the total sample size would be 75.

A sample size list is specified as follows:

<sampleSizeList><v>*sampleSize*</v>...<v>*sampleSize*</v></sampleSizeList>

where each listed *sampleSize* is a positive integer.

### Beta Scale List

The beta scale list includes all scale factors for the regression coefficient, or beta, matrix. The beta scale list is valid for power and sample size requests (it is ignored for detectable difference requests). A beta scale list is specified as follows:

<betaScaleList><v>*betaScale*</v>...<v>*betaScale*</v></betaScaleList>

where each listed *betaScale* is a real number.

### Sigma Scale List

The sigma scale list includes all scale factors for the error covariance matrix. The sigma scale list is required for all requests. A sigma scale list is specified as follows:

<sigmaScaleList><v>*sigmaScale*</v>...<v>*sigmaScale*</v></sigmaScaleList>

where each listed *sigmaScale* is a real number.

### Power Method List

The power method lists includes any combination of the conditional, unconditional, or quantile power methods. It is valid only for study designs involving a baseline covariate (ignored otherwise). Note that only the Hotelling-Lawley and univariate approach to repeated measures are supported for designs with a baseline covariate.

A power method list is specified as follows:

<powerMethodList><v>*powerMethod*</v>...<v>*powerMethod*</v></powerMethodList>

The following power methods are supported:

* conditional - Power values conditional on the specific realization of the baseline covariate values
* unconditional - Power based on numerical integration over possible values of the non-centrality parameter
* quantile - Power based on specific quantiles of the non-centrality parameter's distribution

### Quantile List

The quantile list specifies all quantiles for use with the "quantile" power method. This list is valid only for study designs with a baseline covariate, which specify quantile power in the power method list. A quantile list is specified as follows:

<quantileList><v>*quantile*</v>...<v>*quantile*</v></quantileList>

where each quantile is a real number between 0 and 1.

# The REST API

## Calculating Power

New power calculations are "created" with the following URI:

POST /power/power/

Parameters are specified in the entity body as:

<glmmPowerParameters>

<testList><v>*(hlt|wl|pbt|unirep|unirepBox|unirepGG|unirepHF)*</v>...

<v>*(hlt|wl|pbt|unirep|unirepBox|unirepGG|unirepHF)*</v></testList>

<alphaList><v>*alpha*</v>...<v>*alpha*</v></alphaList>

<sigmaScaleList><v>*sigmaScale*</v>...<v>*sigmaScale*</v></sigmaScaleList>

<sampleSizeList><v>*sampleSize*</v>...<v>*sampleSize*</v></sampleSizeList>

<betaScaleList><v>*betaScale*</v>...<v>*betaScale*</v></betaScaleList>

[<powerMethodList><v>*(conditional|quantile|unconditional)*</v>...

<v>*(conditional|quantile|unconditional)*</v></powerMethodList>]

[<quantileList><v>*quantile*</v>...<v>*quantile*</v></quantileList>]

...*required matrices*...

</glmmPowerParameters>

Power requests must contain all [required matrices](file:///C:\Documents%20and%20Settings\kreidles\My%20Documents\workspace\PowerSvc\docs\api.html#paramsRequiredMatrices:), a testList, an alphaList, a betaScaleList, a sigmaScaleList, and a sampleSizeList.

Power results are returned as:

<?xml version='1.0' encoding='UTF-8' standalone='no'?>

<powerList count='*numberOfResults*'>

<glmmPower alpha='*alpha*' nominalPower='*nominalPower*'

actualPower='*actualPower*' sampleSize='*totalSampleSize*'

betaScale='*betaScale*' sigmaScale='*sigmaScale*' />

...

</powerList>

The powerList tag encloses the list of power results and has a single attribute "count" which specifies the number of results in the list.

The glmmPower tag describes a specific power result and has the following attributes:

|  |  |  |
| --- | --- | --- |
| **Variable** | **Type** | **Description** |
| alpha | Real | Type I error rate associated with this power result. The value ranges from 0 to 1, although 0.01, 0.05, and 0.10 are typical. |
| nominalPower | Real | The desired power for this calculation (specified with sample size or detectable difference requests). For power requests, this value will be equal to the actualPower attribute. |
| actualPower | Real | The actual power associated with this power result. For sample size and detectable difference requests, it may not be possible to perfectly match the desired power for certain study designs. This value will be set to the calculated power associated with the sample size or detectable difference which most closely matches the desired power. |
| sampleSize | Real | The total sample size for this power result |
| betaScale | Real | The scale factor applied to the beta matrix for this power result. This value can be used to generate the beta matrix representing the detectable difference. |
| sigmaScale | Real | The scale factor applied to the error matrix for this power result |

## Calculating Sample Size

New sample size calculations are "created" with the following URI:

POST /power/samplesize/

Parameters are specified in the entity body as:

<glmmPowerParameters>

<testList><v>*(hlt|wl|pbt|unirep|unirepBox|unirepGG|unirepHF)*</v>...

<v>*(hlt|wl|pbt|unirep|unirepBox|unirepGG|unirepHF)*</v></testList>

<alphaList><v>*alpha*</v>...<v>*alpha*</v></alphaList>

<sigmaScaleList><v>*sigmaScale*</v>...<v>*sigmaScale*</v></sigmaScaleList>

<powerList><v>*power*</v>...<v>*power*</v></powerList>

<betaScaleList><v>*betaScale*</v>...<v>*betaScale*</v></betaScaleList>

[<powerMethodList><v>*(conditional|quantile|unconditional)*</v>...

<v>*(conditional|quantile|unconditional)*</v></powerMethodList>]

[<quantileList><v>*quantile*</v>...<v>*quantile*</v></quantileList>]

...*required matrices*...

</glmmPowerParameters>

Sample size requests must include all [required matrices](file:///C:\Documents%20and%20Settings\kreidles\My%20Documents\workspace\PowerSvc\docs\api.html#paramsRequiredMatrices), a testList, an alphaList, a betaScaleList, a sigmaScaleList, and a powerList.

Results are returned as described in the [power results section](file:///C:\Documents%20and%20Settings\kreidles\My%20Documents\workspace\PowerSvc\docs\api.html#powerResults). The sample size results should be extracted from the sampleSize attribute in each glmmPower object.

## Calculating Detectable Difference

New detectable difference calculations are "created" with the following URI:

POST /power/difference/

Parameters are specified in the entity body as:

<glmmPowerParameters>

<testList><v>*(hlt|wl|pbt|unirep|unirepBox|unirepGG|unirepHF)*</v>...

<v>*(hlt|wl|pbt|unirep|unirepBox|unirepGG|unirepHF)*</v></testList>

<alphaList><v>*alpha*</v>...<v>*alpha*</v></alphaList>

<sigmaScaleList><v>*sigmaScale*</v>...<v>*sigmaScale*</v></sigmaScaleList>

[<powerList><v>*power*</v>...<v>*power*</v></powerList>]

[<sampleSizeList><v>*sampleSize*</v>...<v>*sampleSize*</v></sampleSizeList>]

[<betaScaleList><v>*betaScale*</v>...<v>*betaScale*</v></betaScaleList>]

[<powerMethodList><v>*(conditional|quantile|unconditional)*</v>...

<v>*(conditional|quantile|unconditional)*</v></powerMethodList>]

[<quantileList><v>*quantile*</v>...<v>*quantile*</v></quantileList>]

...*required matrices*...

</glmmPowerParameters>

Detectable difference requests must include all [required matrices](file:///C:\Documents%20and%20Settings\kreidles\My%20Documents\workspace\PowerSvc\docs\api.html#paramsRequiredMatrices), a testList, an alphaList, a sigmaScaleList, a sampleSizeList, and a powerList.

Results are returned as described in the [power results section](file:///C:\Documents%20and%20Settings\kreidles\My%20Documents\workspace\PowerSvc\docs\api.html#powerResults). Since regression coefficients are specified as a beta matrix, the "detectable difference" is found in the betaScale attribute of the glmmPower result. For easier interpretation of this value, the beta matrix should have a 1 in cells for groups expected to differ, and a 0 otherwise.

# Examples

## One-Sample T-Test

Suppose we are comparing mean height in sample of 200 adult males against a known height for US males. We will assume a standard deviation of 8 inches (i.e. variance = 64). We would like to determine the power for detecting a difference of 2 inches. We will use the univariate approach to repeated measures as our statistical test, and a type I error rate of 0.05.

To calculate power, we would send the following HTTP request to the Power Service:

POST /power/power

with the entity body (whitespace included for legibility, actual entity bodies for power service should have extraneous whitespace removed):

<glmmPowerParameters>

<alphaList><v>0.05</v></alphaList>

<betaScaleList><v>2</v></betaScaleList>

<testList><v>unirep</v></testList>

<powerMethodList><v>conditional</v></powerMethodList>

<sampleSizeList><v>200</v></sampleSizeList>

<sigmaScaleList><v>64</v></sigmaScaleList>

<matrix name='design' rows='1' columns='1'>

<r><c>1</c></r>

</matrix>

<fixedRandomMatrix name='beta' combineHorizontal='false' >

<matrix name='fixed' rows='1' columns='2'>

<r><c>1</c><c>0</c></r>

</matrix>

</fixedRandomMatrix>

<fixedRandomMatrix name='betweenSubjectContrast' combineHorizontal='true' >

<matrix name='fixed' rows='1' columns='1'>

<r><c>1</c></r>

</matrix>

</fixedRandomMatrix>

<matrix name='withinSubjectContrast' rows='2' columns='1'>

<r><c>1</c></r><r><c>-1</c></r>

</matrix>

<matrix name='theta' rows='1' columns='1'><r><c>0</c></r></matrix>

<matrix name='sigmaError' rows='2' columns='2'>

<r><c>1</c><c>0.5</c></r>

<r><c>0.5</c><c>1</c></r>

</matrix>

</glmmPowerParameters>

This yields the results:

<?xml version="1.0" encoding="UTF-8" standalone="no"?>

<powerList count="1">

<glmmPower actualPower="0.9404375882587327" alpha="0.05" betaScale="2.0"

nominalPower="0.9404375882587327" powerMethod="conditional"

sampleSize="200" sigmaScale="64.0" test="unirep"/>

</powerList>

Indicating that power = 0.94 to detect a difference of 2 inches.

## One-Way ANOVA

Suppose we are comparing resting heart rate in individuals taking three drugs A, B, and C. There are equal numbers of subjects taking each drug. We wish to determine the power for detecting a difference of 5 beats/min between the groups, when there are 10, 15, or 20 subjects in each group. We will use a cell means coding (3x3 identity matrix) for our study design. We assume a within-group variance of 20 and Type I error rate of 0.05.

To calculate power, we would send the following HTTP request to the Power Service:

POST /power/power

with the entity body (whitespace included for legibility, actual entity bodies for power service should have extraneous whitespace removed):

<glmmPowerParameters>

<alphaList><v>0.05</v></alphaList>

<betaScaleList><v>5</v></betaScaleList>

<testList><v>unirep</v></testList>

<powerMethodList><v>conditional</v></powerMethodList>

<sampleSizeList><v>10</v><v>15</v><v>20</v></sampleSizeList>

<sigmaScaleList><v>20</v></sigmaScaleList>

<matrix name='design' rows='3' columns='3'>

<r><c>1</c><c>0</c><c>0</c></r>

<r><c>0</c><c>1</c><c>0</c></r>

<r><c>0</c><c>0</c><c>1</c></r>

</matrix>

<fixedRandomMatrix name='beta' combineHorizontal='false' >

<matrix name='fixed' rows='3' columns='1'>

<r><c>1</c></r>

<r><c>0</c></r>

<r><c>0</c></r>

</matrix>

</fixedRandomMatrix>

<fixedRandomMatrix name='betweenSubjectContrast' combineHorizontal='true' >

<matrix name='fixed' rows='2' columns='3'>

<r><c>1</c><c>-1</c><c>0</c></r>

<r><c>1</c><c>0</c><c>-1</c></r>

</matrix>

</fixedRandomMatrix>

<matrix name='withinSubjectContrast' rows='1' columns='1'>

<r><c>1</c></r>

</matrix>

<matrix name='theta' rows='2' columns='1'>

<r><c>0</c></r><r><c>0</c></r>

</matrix>

<matrix name='sigmaError' rows='1' columns='1'>

<r><c>1</c></r>

</matrix>

</glmmPowerParameters>

This yields the results:

<?xml version="1.0" encoding="UTF-8" standalone="no"?>

<powerList count="3">

<glmmPower actualPower="0.6843301311850237" alpha="0.05" betaScale="5.0"

nominalPower="0.6843301311850237" powerMethod="conditional"

sampleSize="30" sigmaScale="20.0" test="unirep"/>

<glmmPower actualPower="0.8724721326515792" alpha="0.05" betaScale="5.0"

nominalPower="0.8724721326515792" powerMethod="conditional"

sampleSize="45" sigmaScale="20.0" test="unirep"/>

<glmmPower actualPower="0.9543921012167697" alpha="0.05" betaScale="5.0"

nominalPower="0.9543921012167697" powerMethod="conditional"

sampleSize="60" sigmaScale="20.0" test="unirep"/>

</powerList>

This indicates that the design has 68% power with 10 subjects per group, 87% power with 15 subjects per group, and 95% power with 20 subjects per group.

**References**

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*. John Wiley and Sons; 2006.

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