Mixed Model Power Analysis by Example: Using Free Web-based Software

Western North American Region

International Biometric Society

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Grant support

Outline

- **Motivate the need for GLIMMPSE**

- **Introduce the GLIMMPSE software**

- **Present GLIMMPSE validation results**

- **Demonstrate an ANOVA sample size calculation**

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Motivation

- Power and sample size calculation is critical for ethical study design.

- Known results are underutilized.

- Our goal: provide a user-friendly tool for calculating power and sample size.

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What is GLIMMPSE?

- GLIMMPSE is an open-source, online tool for calculating power and sample size for the general linear multivariate model (GLMM) and for a broad class of general linear mixed models (LMM)
  - http://glimmpse.samplesizeshop.com/
- Supported models
  - GLMM/LMM with Gaussian errors and fixed predictors only
  - GLMM/LMM with Gaussian errors and fixed predictors plus a single Gaussian covariate

Related Publications

☐ GLMM with fixed predictors

  ☐ Muller and Peterson, 1984, *Comp Stat and Data Analysis*

  ☐ Muller and Barton, 1989, *JASA*

  ☐ Muller *et al.,* 1992, *JASA*

  ☐ Muller *et al.,* 2007, *Stats in Med*

☐ GLMM with fixed predictors and a Gaussian covariate

  ☐ Glueck and Muller, 2003, *Stats in Med*

Why not SAS or R?

- Need programming expertise to use SAS and R

- Not all researchers have a SAS license
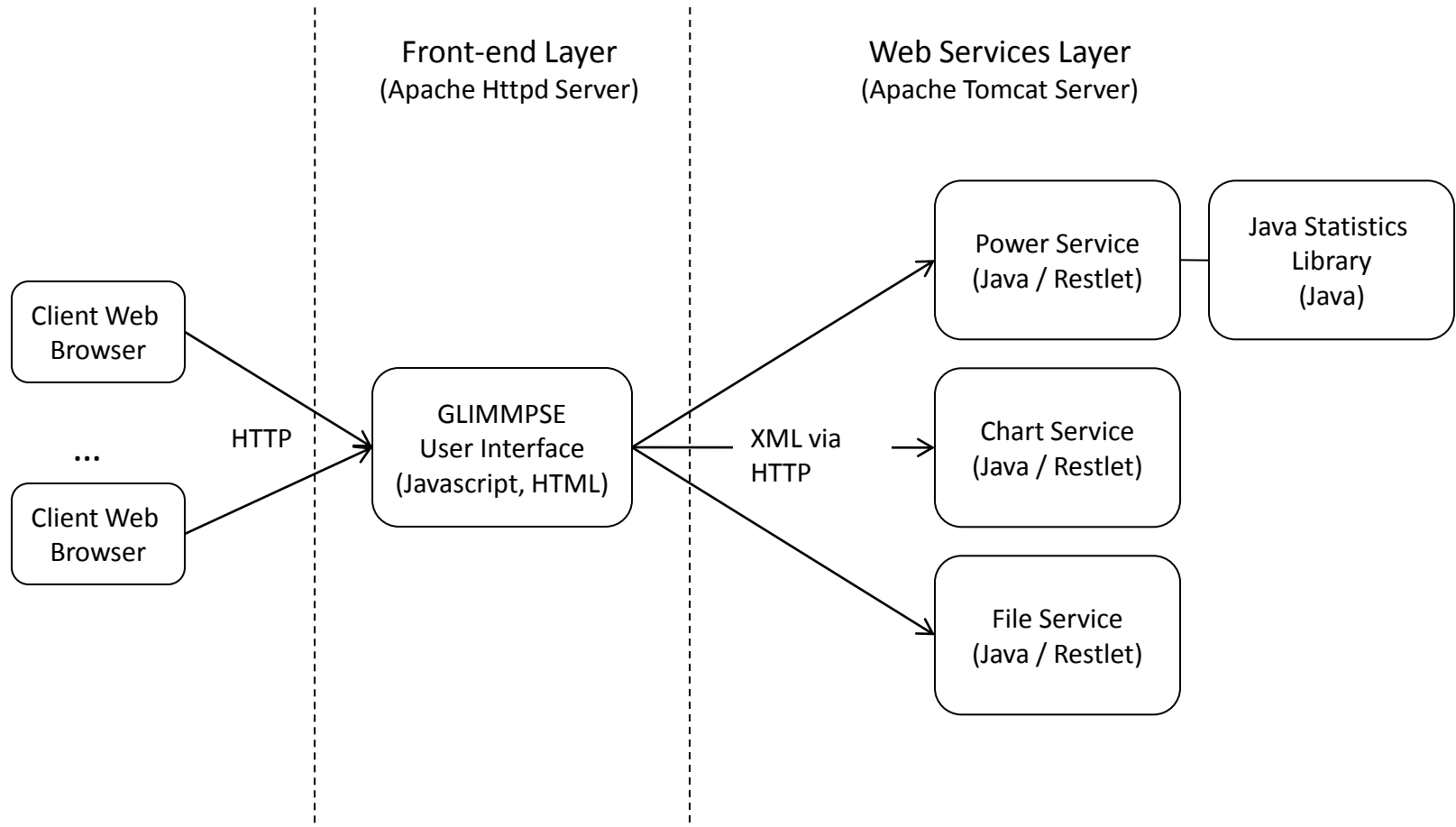
- SAS and R not easily accessible via the web

Why a Web-based Interface?

☐ Web browsers are familiar, widely used; requires zero programming

☐ Java web services is proven technology

  ☐ Free and cross-platform

  ☐ Flexible, scalable framework

  ☐ Encapsulation of power calculation code

  ☐ Allows for future expansion

GLIMMPSE Architecture

Software Team

- Sarah Kreidler, Tech Lead
- Vijay Chander Akula, Software Engineer
- Uttara Sakhadeo, Software Engineer
- Manual Preparation:
  - Zacchary Coker-Dukowitz
  - Brandy Ringham
  - Yi Guo

Two Interaction Modes

- Guided Mode

- Matrix Mode

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GLIMMPSE Accuracy

- Maximum absolute deviation (MAD) used to assess accuracy of GLIMMPSE power values

- Compared to results from published power values and values computed with published software

- Compared to simulation

Validation Results for Fixed Designs

Table 2. Accuracy Results for Power Values in GLMM(F) Designs

Example	Mean Calculation CPU Time (sec. $\times 10^{-4}$)	Mean Simulation CPU Time (sec.)	MAD for GLIMMPSE vs. POWERLIB	MAD for GLIMMPSE vs. Simulation
1	1.3	0.43	9.5×10^{-7}	0.010
2	< 0.1	0.38	2.5×10^{-7}	0.004
3	2.1	0.41	9.0×10^{-7}	0.010
4	8.8	0.46	9.5×10^{-7}	0.006
5	3.6	0.74	9.7×10^{-7}	0.070
6	2.1	2.11	9.6×10^{-7}	0.120
7	< 0.1	1.28	7.7×10^{-7}	0.069
8	6.6	42.47	9.7×10^{-7}	0.053
9 MB*	< 0.1	1.62	6.6×10^{-7}	0.232
9 MEST**	4.2	1.63	8.4×10^{-7}	0.045

* Powers calculated using the F approximation described by Muller and Barton (1989)
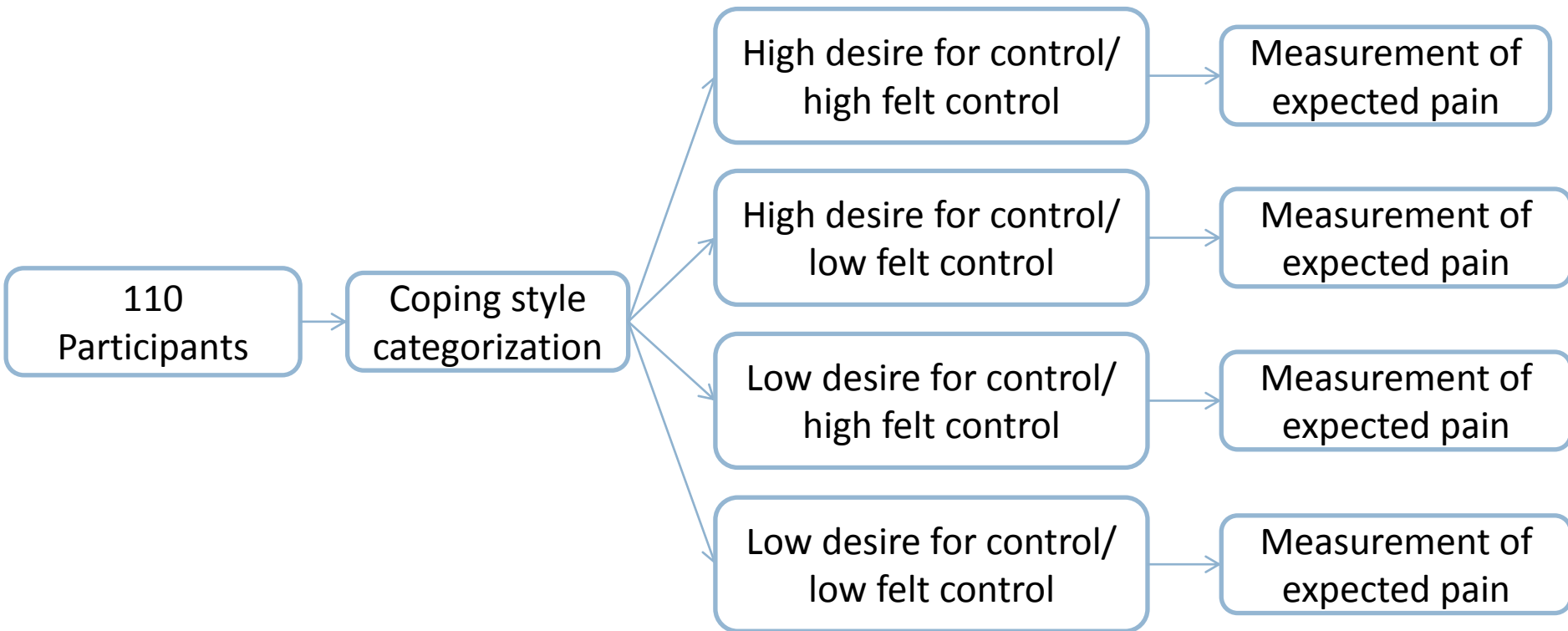** Powers calculated using the F approximation described by Muller *et al.* (2007)

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Power Calculation in Practice: ANOVA

Law *et al.* (1994) studied coping style and expectations of pain with dental treatment

```
                                    ┌─────────────────────┐     ┌──────────────────┐
                                    │ High desire for     │     │ Measurement of   │
                                    │ control/            │────▶│ expected pain    │
                                    │ high felt control   │     │                  │
                                    └─────────────────────┘     └──────────────────┘

                                    ┌─────────────────────┐     ┌──────────────────┐
                                    │ High desire for     │     │ Measurement of   │
                                    │ control/            │────▶│ expected pain    │
                                    │ low felt control    │     │                  │
┌──────────────┐  ┌──────────────┐  └─────────────────────┘     └──────────────────┘
│ 110          │  │ Coping style │
│ Participants │─▶│ categorization│
└──────────────┘  └──────────────┘  ┌─────────────────────┐     ┌──────────────────┐
                                    │ Low desire for      │     │ Measurement of   │
                                    │ control/            │────▶│ expected pain    │
                                    │ high felt control   │     │                  │
                                    └─────────────────────┘     └──────────────────┘

                                    ┌─────────────────────┐     ┌──────────────────┐
                                    │ Low desire for      │     │ Measurement of   │
                                    │ control/            │────▶│ expected pain    │
                                    │ low felt control    │     │                  │
                                    └─────────────────────┘     └──────────────────┘
```

Hypothesis of Interest

☐ Do pre-manipulation expectations of pain with dental treatment differ across individuals with different coping styles?

☐ ANOVA with four coping styles and a single outcome of expected pain

GLIMMPSE Guided Mode

Start Your Study Design

Select one of the options below to begin your power or sample size estimate.

Guided Study Design

Build common study designs including ANOVA, ANCOVA, and regression with guidance from the study design wizard. This mode is designed for more applied researchers including physicians, nurses, and other principal investigators.

Select

Matrix Study Design

Directly enter the matrices for the general linear model. This mode is designed for users with advanced statistical training.

Select

Upload a Study Design

If you have previously saved a study design from GLIMMPSE, you may upload it here. Click browse to select your study design file.

Browse...

Click the select button to enter guided mode

Select a Sample Size Calculation

Start

Type I Error

Design

Coefficients

Contrasts

Null Hypothesis

Variability

Options

Results

Which value are you solving for?

To begin your calculation, please indicate whether you would like to solve for power or total sample size.

If you have a rough idea of the number of subjects you will be able to recruit, then solving for power may be more beneficial.

If you have fewer restrictions on recruitment and would like to ensure a well-powered study, then solving for sample size is likely to be more useful.

○ Power

◉ Total Sample Size

[Previous] [Next]

💾 Save Design
⊘ Help
⊗ Cancel

Enter the Power Values Desired

Start

Type I Error

Design

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Power Values

Enter the desired power values in the list below. Power values are decimals between 0 and 1, with higher values indicating a greater likelihood of correctly rejecting your null hypothesis. Common values are 0.8 or 0.9.

Type the decimal into the listbox and click enter. To remove an item, highlight it and click the "Delete" button

Power Values: [ ] [Add] [Delete]

0.9

Save Design
Help
Cancel

[Previous] [Next]

Enter Type I Error Values

Start

Type I Error

Predictors

Outcomes

Hypotheses

Differences Between Means

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Type I Error

Type I error indicates the probability of incorrectly identifying a significant difference when there is none (i.e. rejecting a true null hypothesis). Type I error values should be decimals between 0 and 1. The most commonly used values are 0.01, 0.05, and 0.1.

Enter the type I error values into the text box and hit enter. You may enter up to 5 values. To remove a value, select it in the list and click the "Delete" button.

Type I Error Values: [   ] [Add] [Delete]

0.01

[Previous] [Next]

💾 Save Design
⊘ Help
⊗ Cancel

Enter Fixed Predictors

Start

Type I Error

Predictors

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💾 Save Design
⊘ Help
⊗ Cancel

Categorical Predictors

In the table below, specify any categorical predictors. Categorical predictors take on a set number of possible values (i.e. categories). A common example of a categorical predictor is treatment group, where research participants may be randomized to a placebo or an active drug group.

Enter the names of all categorical predictors in the left text box. For example, one might enter "drug" and "gender" as predictors.

For each predictor, highlight the predictor name from the list on the left below the "Predictor" text box, and type its associated category names in the "Categories" text box.

For the example above, you would highlight "drug", then enter "placebo" and "active" as categories. Next, you would highlight "gender" and type "male" and "female" as categories.

Predictor			Category		
	Add	Delete		Add	Delete
coping style			high desire / low felt		
			high desire / high felt		
			low desire / low felt		
			low desire / high felt		

Previous   Next

Enter Study Outcomes

Start

Type I Error

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Help
Cancel

Outcomes

Please enter your outcome variables in the table below. Outcomes are the dependent variables in your study. For example, in a study investigating cholesterol-lowering medication, the outcome could be serum cholesterol levels.

Outcomes: [   ] Add   Delete

expected pain

Previous   Next

Select Primary Study Hypothesis

Start

Type I Error

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Cancel

Hypotheses

Based on your study design so far, listed below are some potential hypotheses you may wish to test. Select the hypothesis which most closely resembles your primary study hypothesis. This hypothesis will be used to determine power for your study.

○ The outcomes will differ by coping style

[Previous] [Next]

Specify Clinically Meaningful Differences

Start

Type I Error

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Cancel

Estimated Means

In the table below, enter the approximate means you expect to see for each group in your study. You can enter mean values for each of the outcomes you specified. The groups are listed along the left hand side of the table, and the outcomes are listed across the top. When you are finished, click next to continue.

coping style	expected pain
high desire / low felt	5
high desire / high felt	0
low desire / low felt	0
low desire / high felt	0

Previous   Next

Specify Variability in Expected Pain

Start

Type I Error

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Cancel

Variability in Observed Outcomes

On this screen, you will provide values to indicate the amount of variability in your outcome measures. This is typically reported as standard deviation values in the literature.

What is the standard deviation for the following outcomes?

expected pain 7.6

Previous   Next

Additional Options…

☐ Scale factors for regression coefficients and variability

☐ Confidence intervals

☐ Statistical tests

☐ Power curves

Power Results

Start

Type I Error

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Power Results

Test	Actual Power	Total Sample Size	Beta Scale	Sigma Scale	Alpha	Nominal Power	Power Method	Quantile
unirep	0.9017	244	1.0	1.0	0.01	0.9000	conditional	
unirep	0.9217	132	1.0	0.5	0.01	0.9000	conditional	
unirep	0.9061	488	1.0	2.0	0.01	0.9000	conditional	

Save results | View matrices used for these results

Previous   Next

Matrix Mode for Complex Designs

- Allows direct input of matrices

- Sample size for multilevel and longitudinal designs

- Sample size for reversible mixed models

Example Autoregressive Covariance

Start

Type I Error

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Cancel

Covariance of Errors: Σ_e Matrix

For each independent sampling unit, Σ_e is the covariance of the random errors. For univariate designs, Σ_e will be a 1x1 matrix containing the variance of the error term. More complex structures may be entered for multivariate or repeated measures designs. Values for Σ_e are typically obtained from pilot data or previous studies.

Σ_e is a square, symmetric matrix with dimensions equal to the number of columns in **B**.

Enter values for Σ_e in matrix below.

Σ_e Matrix

3 × 3

1	0.5	0.25
0.5	1	0.5
0.25	0.5	1

Previous   Next

Summary

- GLIMMPSE is an online tool for computing power and sample size for the general linear multivariate model and the mixed model
  - Power for designs with fixed predictors
  - Power for designs with a baseline covariate
- Usable by statisticians and scientists
- Free, web-based, open-source
- Version 2, available soon, will have guided mode for repeated measures, and multilevel designs