PLS205: Experimental Design and Analysis

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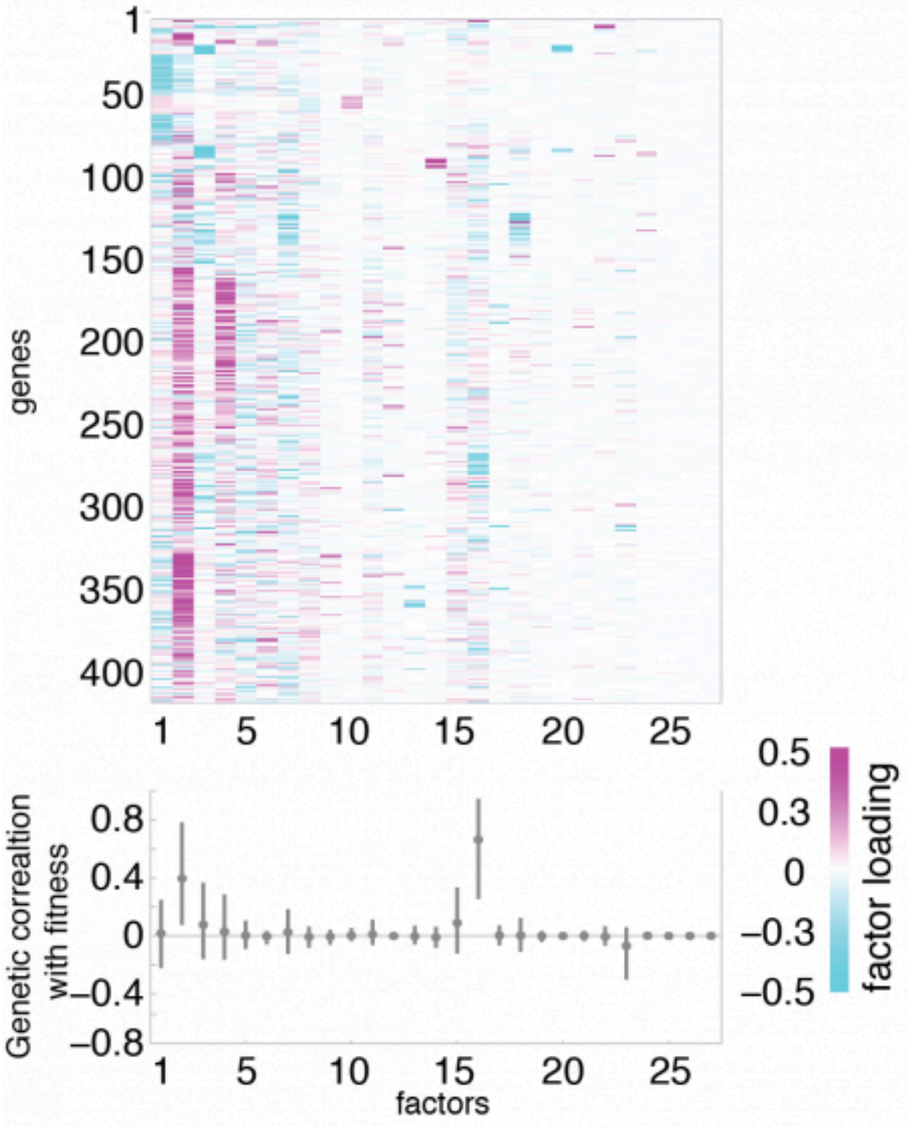
Runcie lab: Plant Genetics and Evolution

maize

Mimulus guttatus

Arabidopsis thaliana



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Experimental Design and Analysis

How do you design a good experiment?

Once you've run an experiment, how do you analyze and communicate your results?

Course Objectives

Be able to choose an appropriate experimental design for a range of experiments

treatments, replication, randomization, blocking

Identify and evaluate experimental designs in the literature

scope, goals, efficiency

Problems? bias, confounding, pseudo-replication

Analyze data from a range of standard experiments with **R**, and communicate results clearly

parameter estimation, hypothesis testing

Produce reports using R Markdown

See Canvas . . .

Course Structure

Lectures	Theory of experimentation and statistical analysis
Labs	Learn to use R to analyze data
Discussions	Misc topics, HW help, R programming
Homework	Weekly problem sets to practice concepts, work in groups
Exams	Midterm and Final, both take-home, done independently

Course Format

Lectures

Combination of slides and blackboard

Frequent activities and group discussions

Labs

Guided demonstrations of R skills

Discussions

Group-based problem solving

Grading

	% of total	Date
Homework	40%	Due Thursdays before class, partially peer-graded
Midterm exam	30%	2/10 (Due 2/15)
Final exam	30%	3/16 (Due 3/22)

Homework grades are due 1 week later. Peer-grades are worth 25%.
You'll lose 10% per day for late assignments or late peer-grades

How to do well

Take advantage of Discussion sections and office hours

- Come to me or TAs **early** in the quarter if you're having problems

Ask questions!

Use online resources for learning **R** and **R Markdown**

Work together on homework (but turn in your own work)

- Find peers and post questions on Piazza

Do peer-grades of homework on-time and comprehensively

Etiquette

- Be respectful of others
  - Respond to questions/comments of others in a constructive way
  - Participate in class discussions
    - “Step up / Step back”
    - “Three before me”
- Connect with others when you can
  - Form study-groups. Invite others to join you when they ask

Prereq's

STAT 100 or PLS 120 or equivalent

- t-test
- ANOVA
- Distributions (normal, Student's t)
- Hypothesis test

Experience with R (or another programing language) is not required

- Make use of online resources for R help
  - Intro R tutorials
  - R Markdown

Resources

Textbook (not required): Statistical Methods in Biology: Design and Analysis of Experiments and Regression S. J. Welham, S. A. Gezan, S. J. Clark and A. Mead. CRC Press

Online courses for experimental design

PSU Stat 503

3Rs- Reduction.co.uk

Office hours

See Canvas

Assignments, Announcements, Downloads

See Canvas

Let’s run an experiment ...

Question: Does standing up increase a person's pulse?

I assigned each of you to one of two treatments (sitting / standing).

Standing treatment

Arballo, Joseph	Fraile Reyes, Maria de la Paz	Khan, Raja Zabeeh Ull	Noone, Rachel	Shabnam, Shabnam
Beckert, Samantha	Fuentes, Abelina	Khanal, Samjhana	Park, Gen Ha	Sondag, Delaney
Beech, Ava-Rose	Godbey, Mia	Lokuhitige, Sandy	Pham, Anh Khoa	Sun, Cynthia
Bilal, Abdul Rehman	Harris, Leila	Mafakheri, Mohammad	Pierce, Alice	Ulep, Francis
Bowman, Jennifer	Hight, Christopher	Magee, Connor	Reyes Gallegos, Elizabeth	Waldman, Kira
Chukwuere, Comfort	Hoffman, Laurel	Morimoto, Kevin	Rizzo, Natalie	Xu, Yichao
Collinson, Myles	Huber, Liam	Muhammad, Imani	Rollins, Marlynn	Yvºksel, Pelin
Duman, Konshau	Hudson, Nick	Navazesh, Shya	Salbato, Sophia	Zhang, Xiaolu
Escalona, Erika	Jennings, Krysta	Noland, Landin	Salman, Saleh	

Let’s run an experiment ...

Question: Does standing up increase a person's pulse?

I assigned each of you to one of two treatments (sitting / standing).

You will count your pulse for 30 seconds. On “Ready”, get in position and find your pulse. On “Go”, start counting…

Ready . . . Set . . . Go!

Stop!

Pulse (beats per minute) = count x 2

Record your pulse in the Google Form sent by email

Thought question

Was this a good experiment?

- Was it a **valid** experiment?
- What specifically can we learn from it?
- How could it have been improved?

Experiment

An exercise designed to determine the **effects** of one or more variables (**treatments**) on one or more characteristics (**response variables**) of some well-defined system (**experimental unit**).

Hurlbert 2004

Goal of Experimentation

Draw conclusions about treatment effects

Generalize results to a broader population

Components of an Experiment

Research Question

Experimental Design

Analysis Plan

Research Question

What do you want to learn?

Motivated by a hypothesis

Size / **Magnitude** of the effect of a manipulation of a system

Comparison between different classes (treatments)

Scope / reference population

ability to generalize

Experimental Design

Treatment Structure

Treatment: Conditions imposed by the experimenter

Each **treatment factor** has 2+ **levels**

Goal: Comparisons among **levels**

Design Structure

What will you apply the treatments to? **Experimental Units (EU)**

How will you avoid bias and control noise? Randomization, Covariates, Blocks

Replication

Response Structure

What will you measure?

Experimental Unit

The **smallest** unit of experimental material to which a **single treatment** (or treatment combination) is assigned by the experimenter and which is dealt with **independently** of other such systems **under that treatment** at **all stages in the experiment** at which important variation may enter.

Kozlov and Hurlbert 2006

Each experimental unit get its treatment **independently**

Each experimental unit is **equally likely** to be assigned each treatment

Experimental units shouldn’t **interfere** with each other

Experimental units should be **randomly** selected from a **reference population**

Analysis Plan

How do you turn your data into a result?

- Assess data quality
- Make comparisons among groups exposed to different treatments
- Report **estimates** and **uncertainty**

How can you interpret / generalize from your conclusions?

How to analyze an experiment

Scientific Importance

Research Question

Efficiency

Experimental Design

Experimental execution

Appropriate allocation of resources

Validity

Analysis

Interpretation

Appropriate controls

Honest statements of uncertainty

Experimental validity

Research Question

What do you **want** to know?

Experimental Design and Analysis

What did you actually measure?

"Internal validity"

Mathematical validity

Lectures

Labs

Interpretation

Does what you measured actually address your research question?

"External validity"

Scientific validity

Reading:

Hurlbert 1984

Pseudoreplication and the Design of Ecological Field Experiments

Stuart H. Hurlbert

Ecological Monographs, Volume 54, Issue 2 (Jun., 1984), 187-211.

For Thursday:

Read up to section “Critical features of a controlled experiment”

Be prepared to discuss whether our pulse experiment was a mensurative or a manipulative experiment

For HW1:

Select a paper describing an experiment relevant to your research

Analyze this experiment based on Table 1 of Hurlbert 1984