Designing animal experiments: old and new paradigms

Quentin Read

SEA Statistician

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What is experimental design?

What is power?

Old and new ways of designing experiments

Old and new ways of estimating power

Pitfalls of the new approach

AI or just statistics?

What is experimental design?

Experiment: procedure that manipulates X to learn about the effect of X on Y

Principles of experimental design:

What is power?

IACUC requires you to show that your experiment has adequate **power**

But what is power and how does it relate to experimental design?

What is power? continued

POWER = the probability that a test will detect a phenomenon, if it really exists

POWER = the ability of our study to give a reliable answer to the questions we care about

We can never know the truth for sure, we can only have a certain level of confidence in our statistical estimates

Power: an example

TRUTH = mice that eat 50 g of celery every day have 10% lower obesity rate than those who do not eat celery

> *If a certain study design has 80% power to detect the 10% difference at a significance level of 0.05, then if we were to repeat that study many times, we would see a significant effect of celery 80% of the time.*

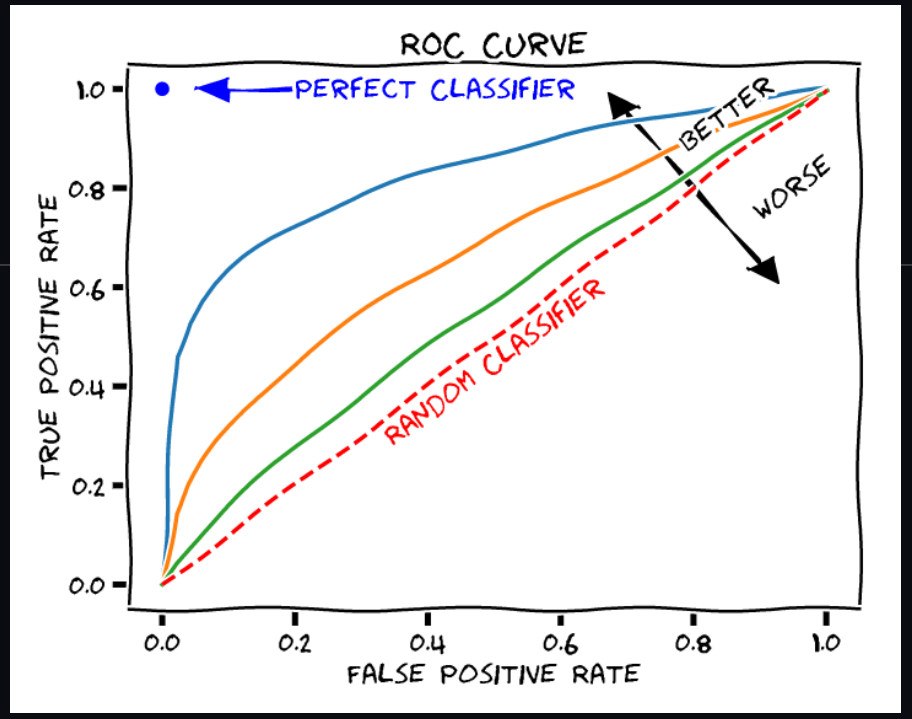
We can be wrong in two ways

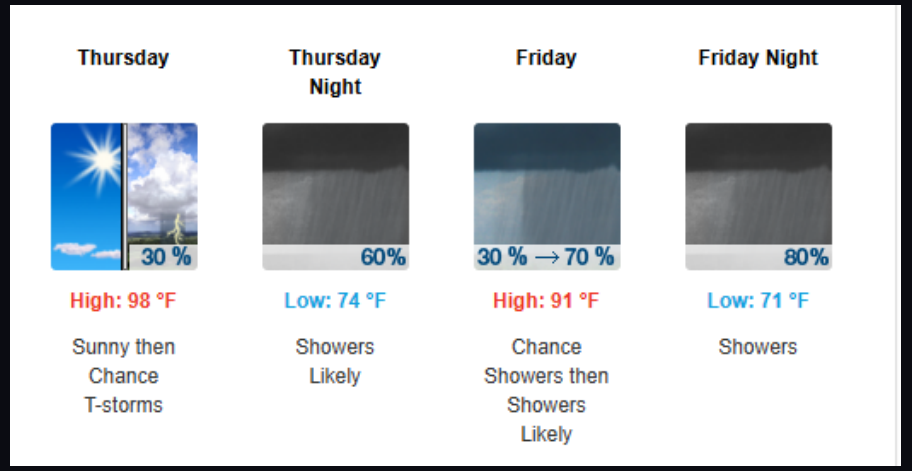
False positives and false negatives

Reminder: *we never know the truth, we can only estimate*

Find the “sweet spot”

Diminishing returns





Components of experimental design

Experimental design choices

maximize efficiency of design and minimize resources spent/harm done to research subjects

- **Efficient** = best able to answer the question you care about, given the resources you have
- Standard/simple designs may not be the most efficient!

Experimental design: old way versus new way

Old way

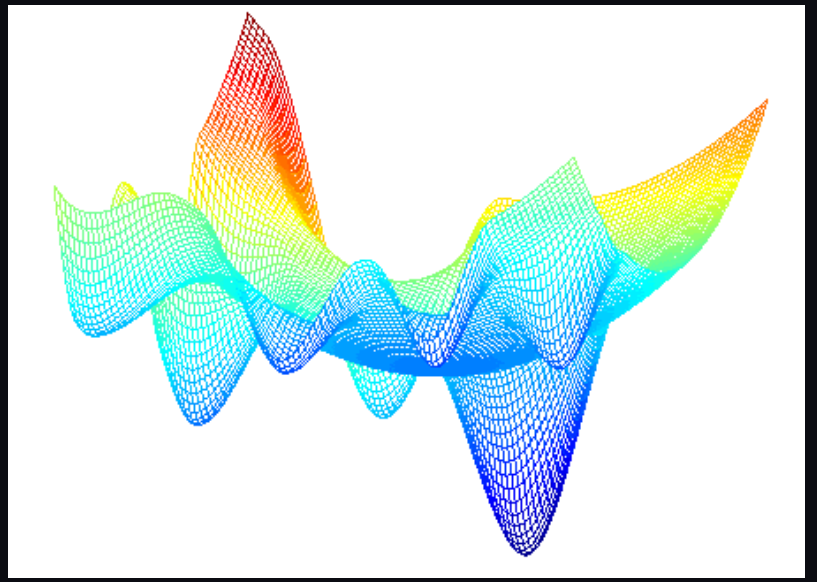
"OFAT" = One Factor At a Time

New way

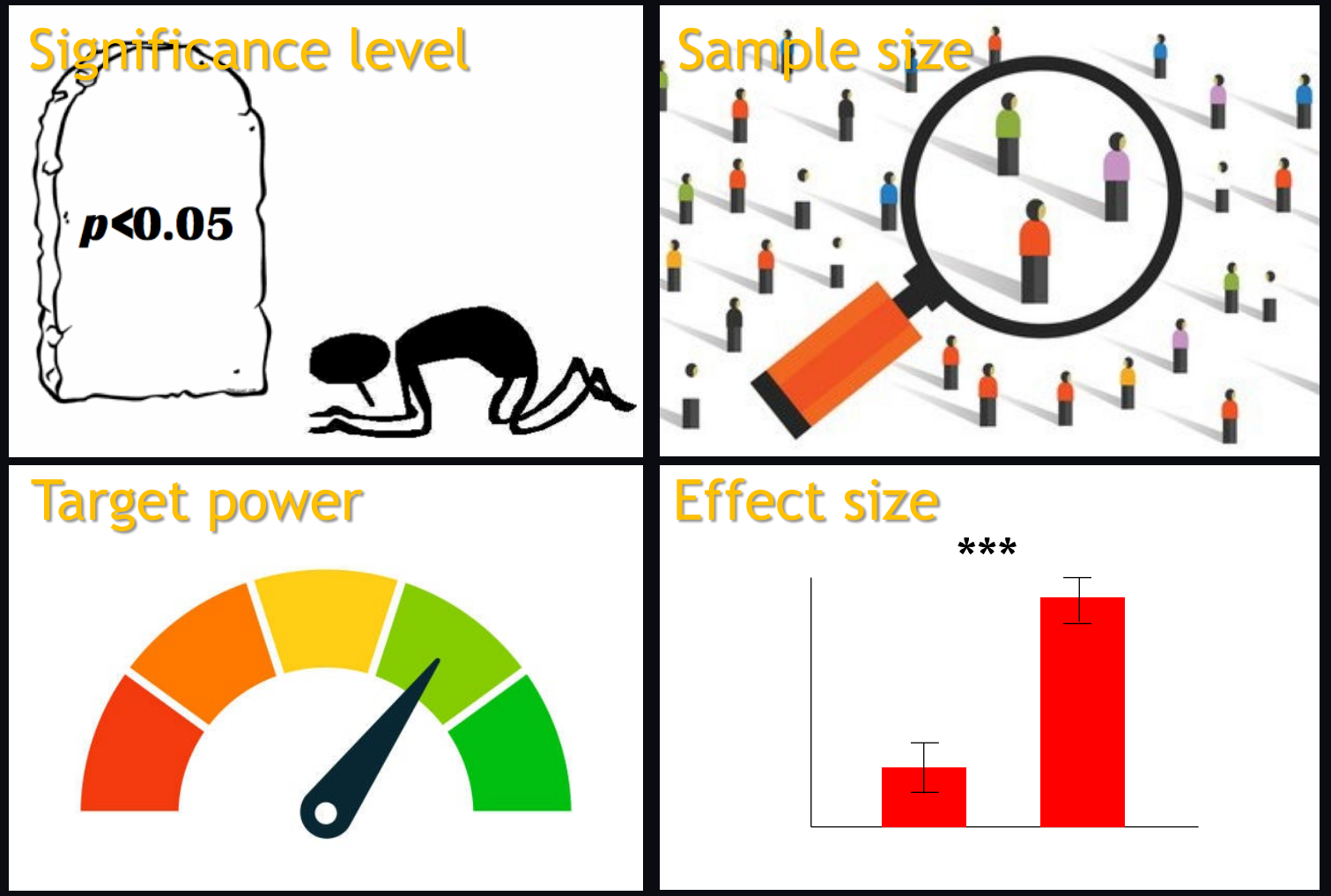
Adaptive; Bayesian optimization

Most efficient design, given your constraints

Collect data as needed



What do we need to know for power calculations?



Effect size

Expressed in standardized units

Example: mean of treatment group is 0.7 standard deviations greater than mean of control group

You need to know variance *within* treatment groups relative to the difference *between groups*

You also need to know variance due to other factors in your experimental design (such as variance between means of the blocks)

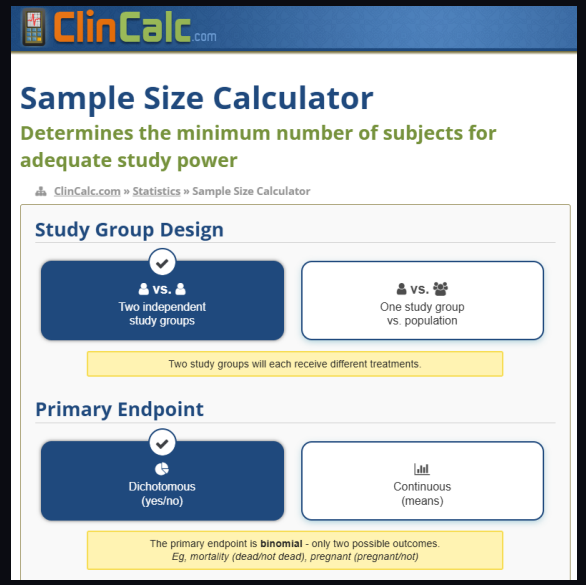
Effect size estimation: old way vs. new way

Old way

Plug numbers into a desktop or online calculator

Use single estimate of effect size

Formula gives you an “exact” answer

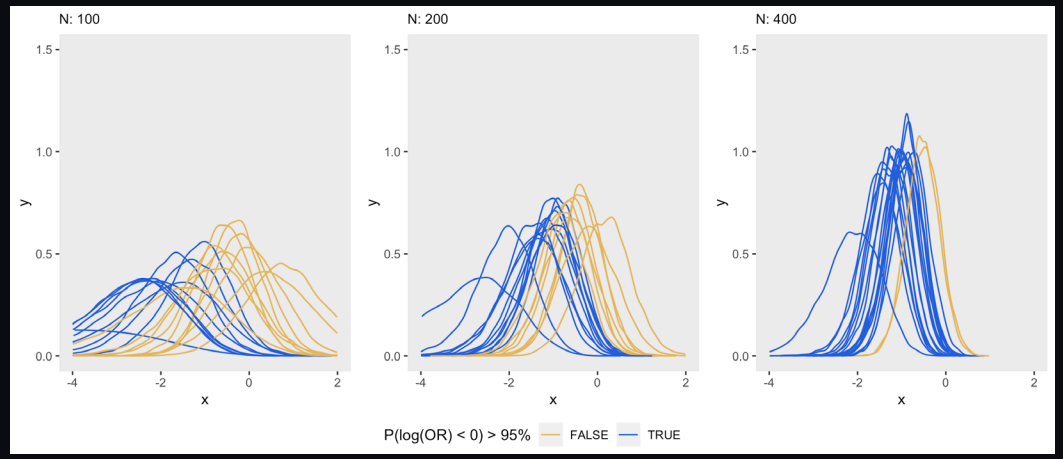


New way

Rapidly get a range of effect sizes from the literature

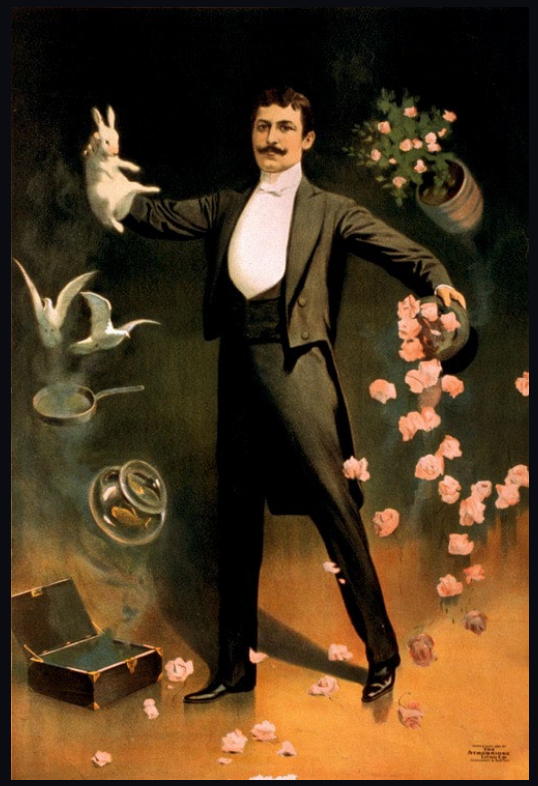
Play with a range of assumptions

Simulation-based power analysis



Pitfalls

Garbage in, garbage out:
Bad assumptions → bad analysis



If you don’t know how you got a number, it might as well be magic

AI or just statistics?

New paradigm of experimental design and power analysis:

- Explore all possible designs to find the most efficient one
- Use all available information to find ranges of effect sizes
- Simulations to test different assumptions and estimate power for complex models and designs

AI can be used for that.

Statisticians can also be used for that!