Advantages of Formal Designs

- Prevents bias
- More likely to have accurate results
- Risk of self-deception avoided by design choices
- Some elements required for statistical analysis
- In medicine and agriculture very productive

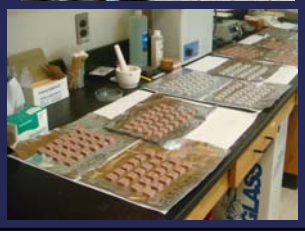
Scientific Method and Experimental Design in Preservation and Conservation Research:

Part II: Basic Concepts of Experimental Design

- Object Protocols
- Measurement Protocols
- Treatment Protocols

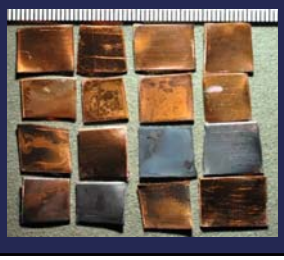
OBJECT PROTOCOLS

- Real or facsimile?
- How many replicates?



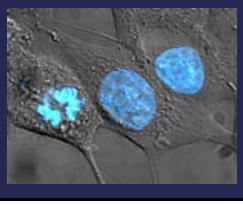
Purpose of Properly-Designed Experiments on Simulated Objects

- Good experimental design, testing, and analysis helps us objectively separate treatments that work from those that don't
- Example: Treatment-created disaster at rock art sites of American Southwest

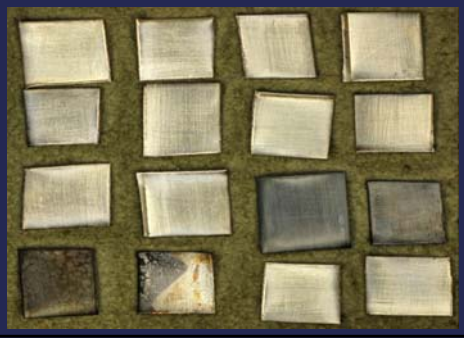


Purpose of Replicates

- To identify random variation in objects, measurements, and treatments so can
  - Estimate variability
  - Estimate actual treatment effects more accurately



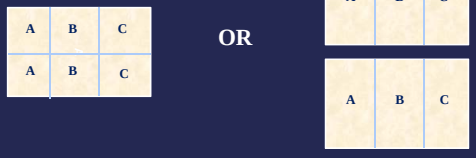
Oddy Test Coupons



What Constitutes a Replicate?

A paper/adhesive study

What Constitutes a Replicate?



Testing a treatment for natural history skins

MEASUREMENT PROTOCOLS

- Variable types
- Repeated readings
- Repeated measurements
- Avoidance of bias
  - Randomization
  - Blinding

Repeated Readings

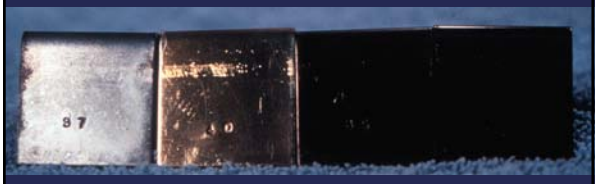
- Purpose: to increase accuracy by averaging out measurement error (instrument noise, reading errors)
- So average the data; instrument protocols often exist

Repeated Measurements

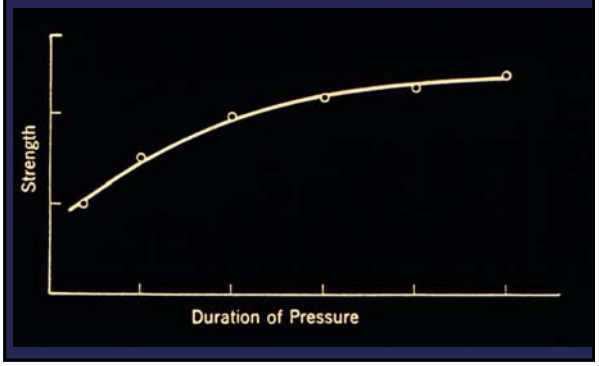
- Purpose is to detect spatial or temporal variation or change, so NOT averaged
- Example: Before and after treatment
- Importance of limiting these to what is meaningful and reasonable

From *The Cartoon Guide to Statistics*, 1993

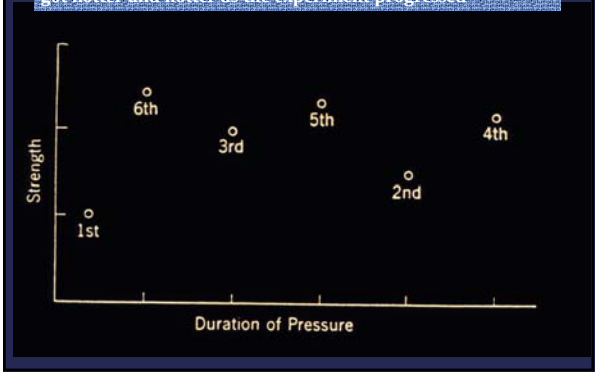
Assigning numbers for randomization procedures, blind analysis

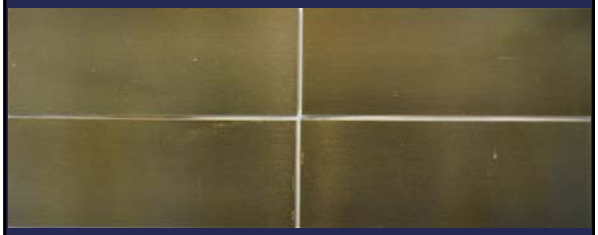


(Wilson 1991) Plastic parts, length of time pressed in mold appeared at first to be related to final strength of the part



But when pressing length was randomized, it was clear there was no relationship. Concluded it was heat of mold, which got hotter and hotter as the experiment progressed



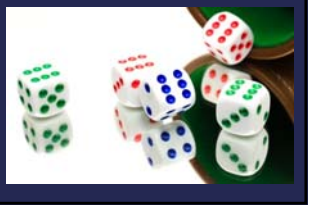


Blinding

- Taking measurements or assessing results without knowing which sample received which treatment
- Crucial for subjective measurements or assessments
- Example: Placebo in medicine

TREATMENT PROTOCOLS

- Controls
- Randomization

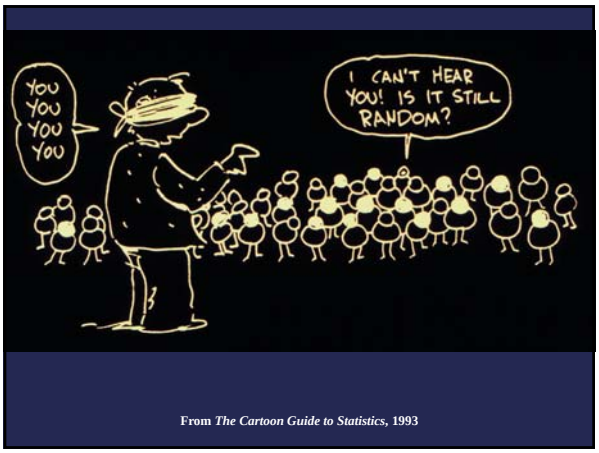


Controls

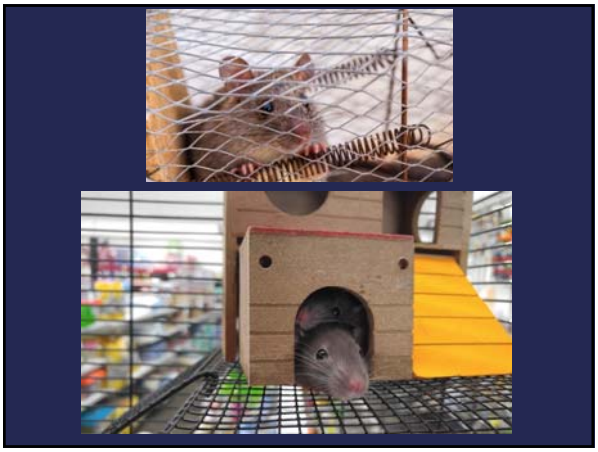
- Receive either no treatment or a standard comparative treatment
- Purpose is to ascertain that effects are due to treatment not to chance or an uncontrolled factor
- If comparing one treatment to another, don't need a third control group

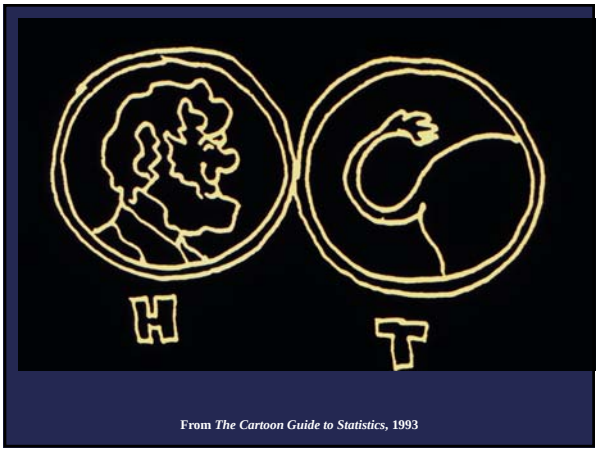
Randomization

- Statistical tests assume treatments were assigned randomly
- Prevents bias in selection of which objects get which treatment
- Distributes uncontrolled factors among treatment groups, so one treatment will not appear different from another when it actually is not

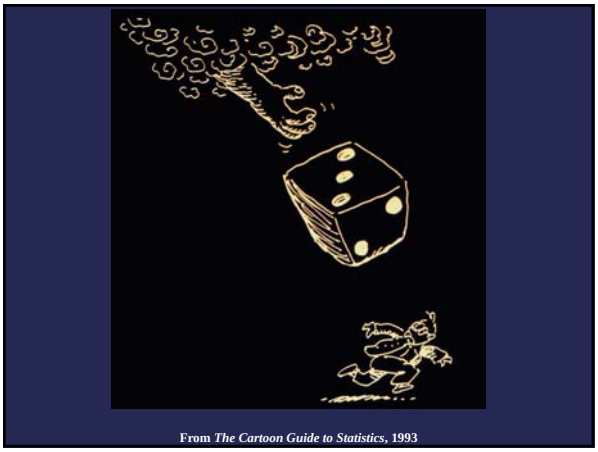


From *The Cartoon Guide to Statistics*, 1993





From *The Cartoon Guide to Statistics*, 1993

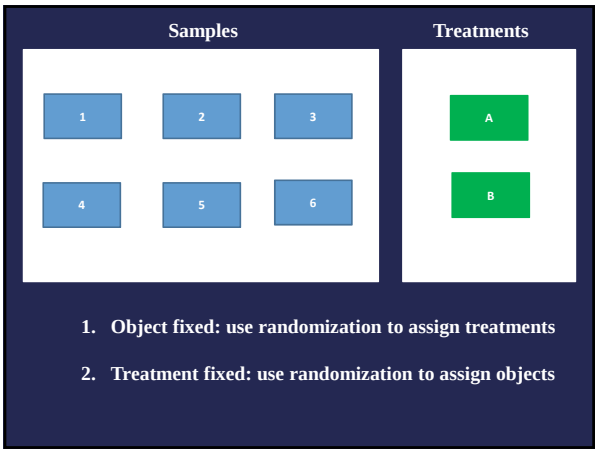


From *The Cartoon Guide to Statistics*, 1993

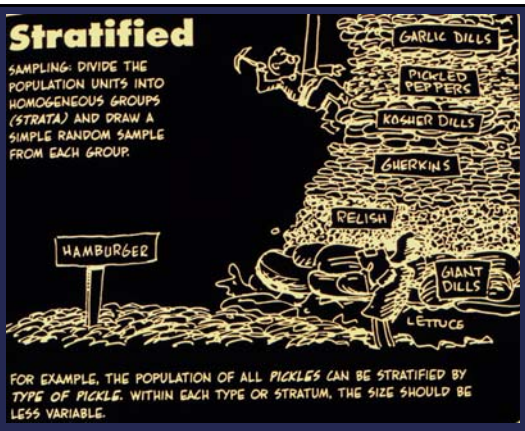
```
3083184729825154082818 4
3415760719312473013084 4
7516689039089208012007 9
8284724061326313816935 9
9121230752917072954818 7
7978607713667584916032 8
2088392480466135057899 0
3044439608267673779506 6
6598250124487245713721 6
3494168105382456224491 4
3302268349872943418481 4
1726609682320311218881 6
7917970422304081694356 3
7277884704387303903764 8
1651713153207028888065 3
8484927860044287636760 9
6952921917771667687842 6
1299297539224627826142 7
9737351608198569471655 6
2363929724282123850242 9
```

DRAWING ASSIGNMENTS FROM A JAR

- An easy method to randomly assign a small or large number of specimens to a small or large number of treatment groups
- Requires papers be well mixed and not identifiable while in jar



1. **Object fixed: use randomization to assign treatments**
2. **Treatment fixed: use randomization to assign objects**



From *The Cartoon Guide to Statistics*, 1993

From *The Cartoon Guide to Statistics*, 1993