CS160: User Interface Design

Data Analysis 03/07/12

Berkeley
UNIVERSITY OF CALIFORNIA

Touch Projector:
Mobile Interaction through Video

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Plan Through Midterm

Today 3/7:
Statistics & Analyzing Study Data

Monday 3/12:
Midterm Review
Due: Lo-fi test with three users

Wednesday 3/14:
In-class Midterm

Midterm on 3/14

In class. 75 minutes
Closed book & notes
Review on Monday 3/12

If you are registered with the DSP office and have special needs, we need to see your letter by **today** at 1pm to make accommodations.

Designing Controlled Experiments

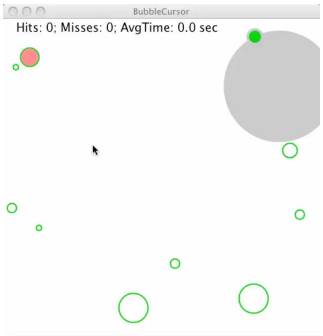
Variables

Independent variables
Cursor type (bubble, normal, area?)
Target Distance
Target Width (Effective vs. Actual?)

Dependent variables
Movement Time
Error Rate
User Satisfaction

Control variables
Color scheme, input device, screen size

Random variables
Location, environment,
Attributes of subjects
Age, gender, handedness, …



Conducting studies online vs. in person strongly influences which variables are controlled and which are random.

Choosing Subjects

Pick balanced sample reflecting intended user population

Novices, experts

Age group

Sex

….

Example

12 non-colorblind right-handed adults (male & female)

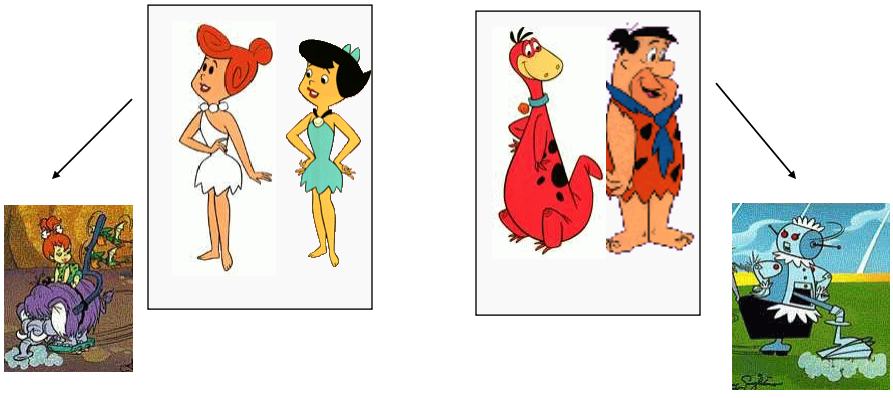
Population group can also be an IV or a controlled variable

What is the disadvantage of making population a controlled var?

Between Subjects Design

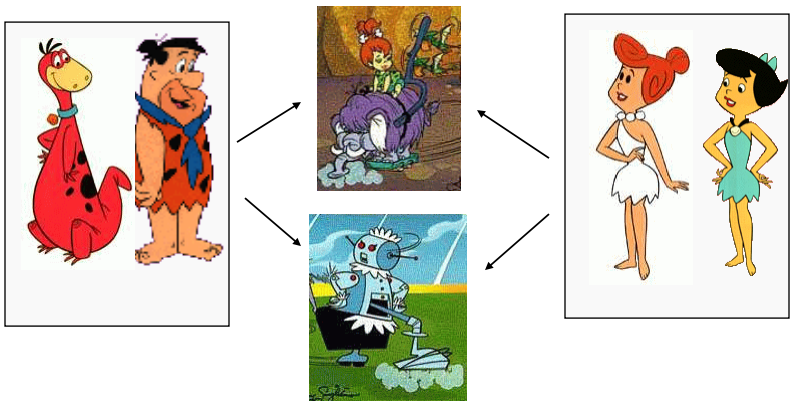
Wilma and Betty use one interface

Dino and Fred use the other



Within Subjects Design

Everyone uses both interfaces



Between vs. Within Subjects

Between subjects

Each participant uses one condition

+/- Participants cannot compare conditions

+ Can collect more data for a given condition

- Need more participants

Within subjects

All participants try all conditions

+ Compare one person across conditions to isolate effects of individual diffs

+ Requires fewer participants

- Fatigue effects

- Bias due to ordering/learning effects

Within Subjects: Ordering Effects

In within-subjects designs ordering of conditions is a variable that can confound results

Why?

Turn it into a random variable

Randomize order of conditions across subjects

Counterbalancing (ensure all orderings are covered)

Latin square (partial counterbalancing)

…

Run the Experiment

Always pilot it first!

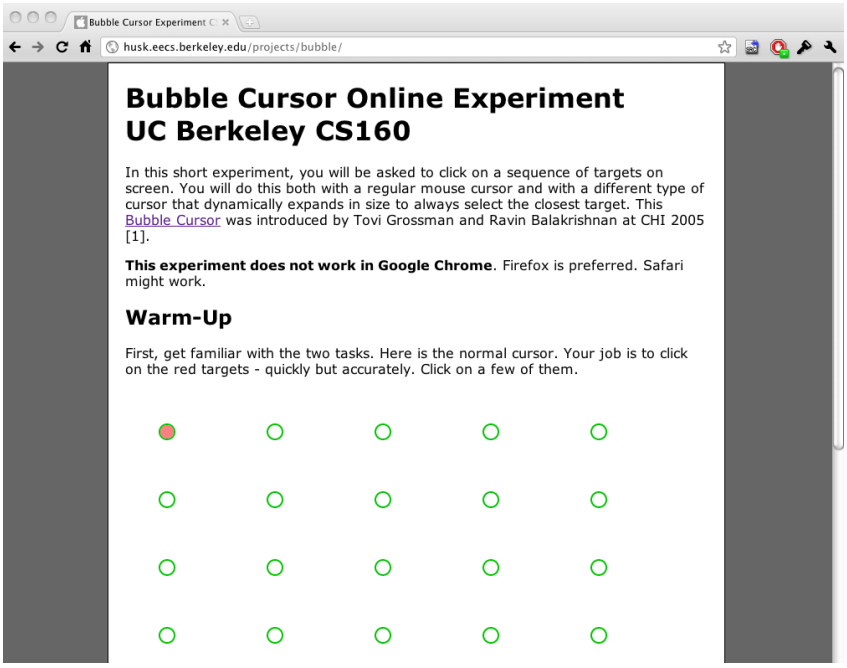
Reveals unexpected problems

Can't change experiment design after starting it

Always follow same steps – use a checklist

Get consent from subjects

Debrief subjects afterwards



Managing Study Participants

Run the Experiment

Always pilot it first!

Reveals unexpected problems

Can't change experiment design after starting it

Always follow same steps – use a checklist

Get consent from subjects

Debrief subjects afterwards

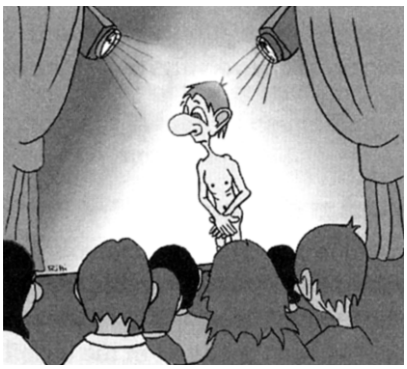
The Participants' Standpoint

Testing is a distressing experience

Pressure to perform

Feeling of inadequacy

Looking like a fool in front of your peers, your boss, …



(from "Paper Prototyping" by Snyder)

The Three Belmont Principles

Respect for Persons

Have a meaningful consent process: give information, and let prospective subjects freely chose to participate

Beneficience

Minimize the risk of harm to subjects, maximize potential benefits

Justice

Use fair procedures to select subjects
(balance burdens & benefits)

To ensure adherence to principles, most schools require Institutional Review Board approval of research involving human subjects.

Ethics: Stanford Prison Experiment

1971 Experiment by Phil Zimbardo at Stanford

24 Participants – half prisoners, half guards ($15 a day)
Basement of Stanford Psychology bldg turned into mock prison
Guards given batons, military style uniform, mirror glasses,…
Prisoners wore smocks (no underwear), thong sandals, pantyhose caps

Experiment quickly got out of hand

Prisoners suffered and accepted sadistic treatment
Prison became unsanitary/inhospitable
Prisoner riot put down with use of fire extinguishers
Guards volunteered to work extra hours

Zimbardo terminated experiment early

Grad student Christina Maslach objected to experiment
Important to check protocol with ethics review boards

[from Wikipedia] http://www.youtube.com/watch?v=rmwSC5fS40w

Ethics: Stanford Prison Exp. Video

http://www.youtube.com/watch?v=Z0jYx8nwjFQ

Ethics (more recently)

"In 2001, a faculty member […] designed a study to see how restaurants would respond to complaints […]

As part of the project, the researcher sent letters to restaurants falsely claiming that he and/or his wife had suffered food poisoning that ruined their anniversary celebration.

The letters […] stated that the only intent was to convey to the owner what had occurred "in anticipation that you will respond accordingly."

Restaurant owners were understandably upset and some employees lost their jobs before it was revealed that the letter was a hoax."

CITI Human Subject Training Material

Beneficience: Example

MERL DiamondTouch:

User capacitively coupled to table through seating pad.

No danger for normal users, but possibly increased risk for participants with pacemakers.

Inform subjects in consent!

http://www.merl.com/projects/images/DiamondTouch.jpg

Privacy and Confidentiality

Privacy: having control over the extent, timing, and circumstances of sharing oneself with others.

Confidentiality: the treatment of information that an individual has disclosed with the expectation that it will not be divulged

Examples where privacy could be violated or confidentiality may be breached in HCI studies?

Treating Subjects With Respect

Follow human subject protocols

Individual test results will be kept confidential

Users can stop the test at any time

Users are aware (and understand) the monitoring technique(s)

Their performance will not have implications on their life

Records will be made anonymous

Use standard informed consent form

Especially for quantitative tests

Be aware of legal requirements

Conducting the Experiment

Before the experiment

Have them read and sign the consent form

Explain the goal of the experiment in a way accessible to users

Be careful about the demand characteristic
(Participants biased towards experimenter's hypothesis)

Answer questions

During the experiment

Stay neutral

Never indicate displeasure with users performance

After the experiment

Debrief users (Inform users about the goal of the experiment)

Answer any questions they have

Managing Subjects

Don't waste users' time

Use pilot tests to debug experiments, questionnaires, etc…

Have everything ready before users show up

Make users comfortable

Keep a relaxed atmosphere

Allow for breaks

Pace tasks correctly

Stop the test if it becomes too unpleasant

If you want to learn more…

Online human subjects certification courses:

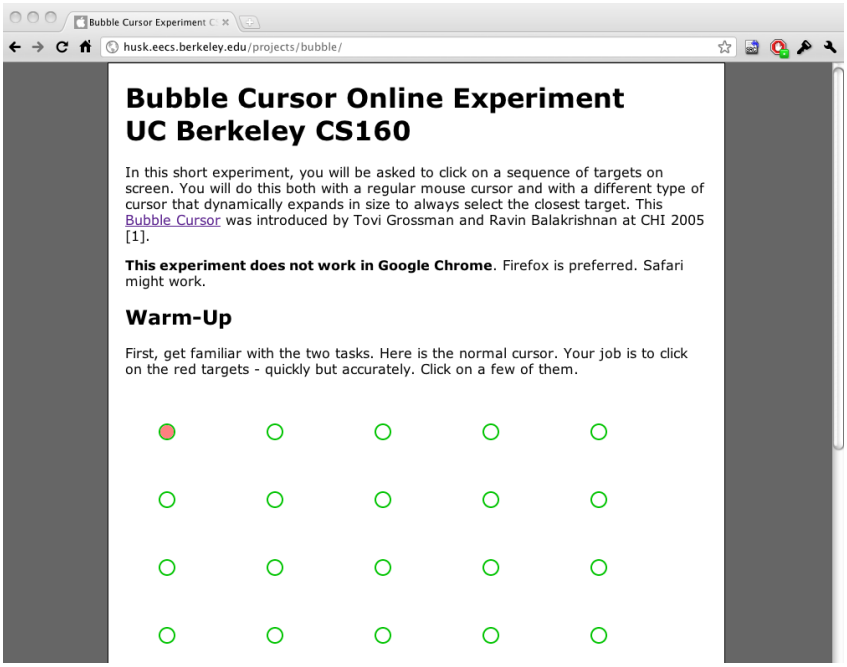
E.g., http://phrp.nihtraining.com/users/login.php

The Belmont Report: Ethical Principles and Guidelines for the protection of human subjects of research

1979 Government report that describes the basic ethical principles that should underly the conduct of research involving human subjects

http://ohsr.od.nih.gov/guidelines/belmont.html

Data Analysis



Start by counting

```
1700 trials total

normal: mean time 966.3 ms, mean errors 1.286
bubble: mean time 758.8 ms, mean errors 0.279
```

Start by counting

```
21 users completed condition normal, size 10
mean time: 1129.37 ms, mean errors: 0.08
median time: 1055 ms, median errors: 0

21 users completed condition normal, size 30
mean time: 803.24 ms, mean errors: 0.05
median time: 766 ms, median errors: 0

21 users completed condition bubble, size 10
mean time: 796.22 ms, mean errors: 0.01
median time: 751 ms, median errors: 0

22 users completed condition bubble, size 30
mean time: 723.04 ms, mean errors: 0.02
median time: 701 ms, median errors: 0
```

Descriptive Statistics

Continuous data:

Central tendency

mean, median, mode

Dispersion

Range (max-min)

Standard deviation

Shape of distribution

Skew, Kurtosis

Categorical data:

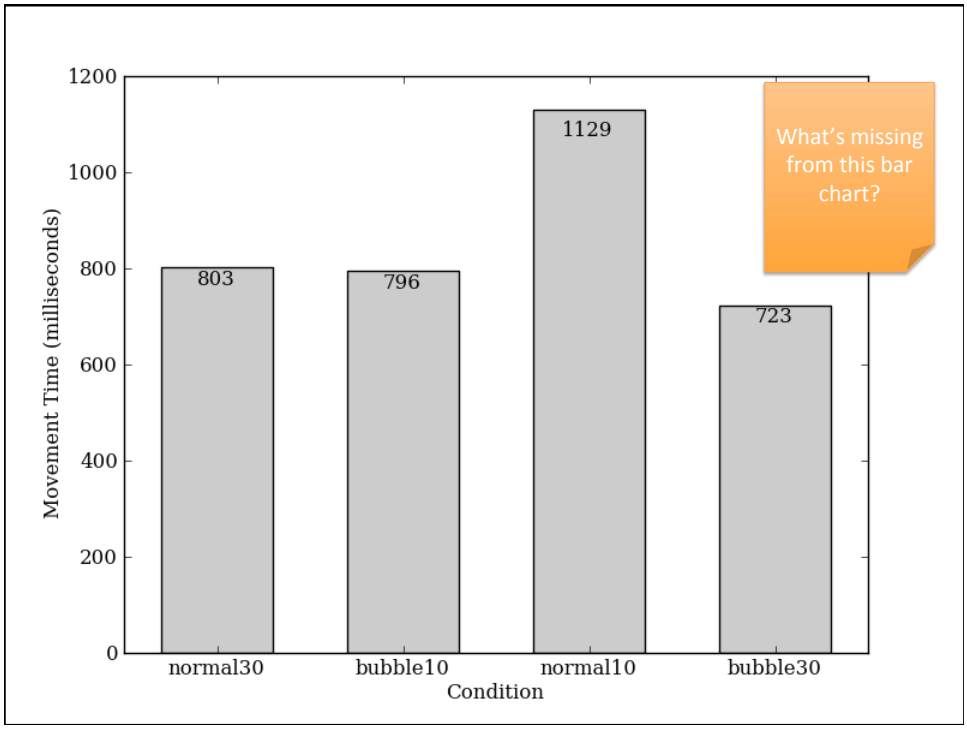
Frequency distributions

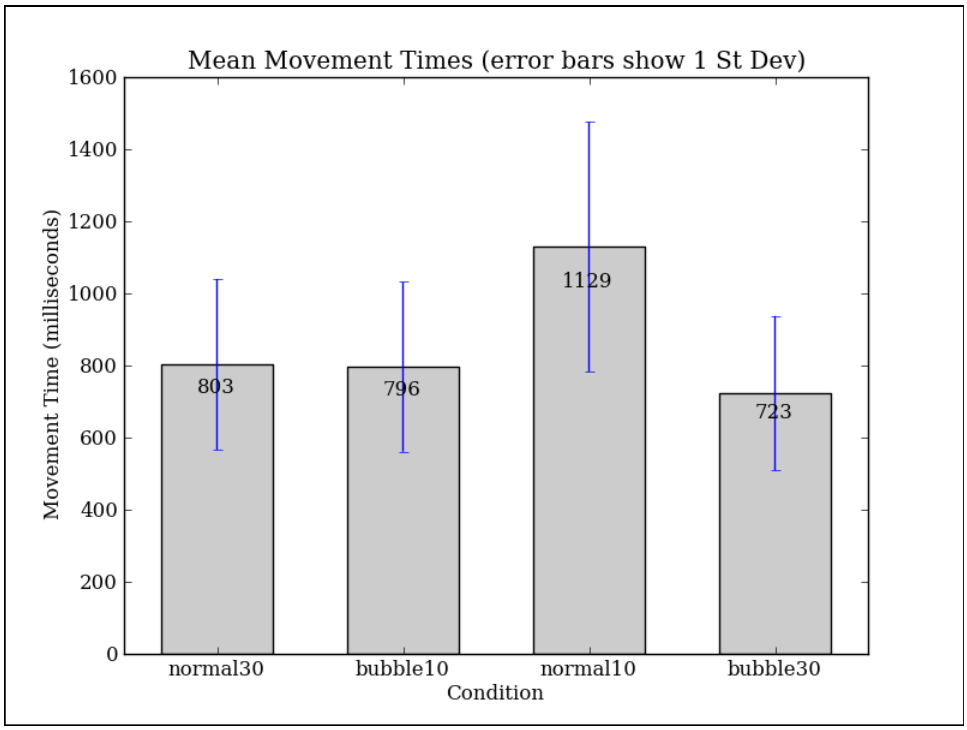
$$\mu = \frac{\sum_{i=1}^{N} X_i}{N}$$

Mean

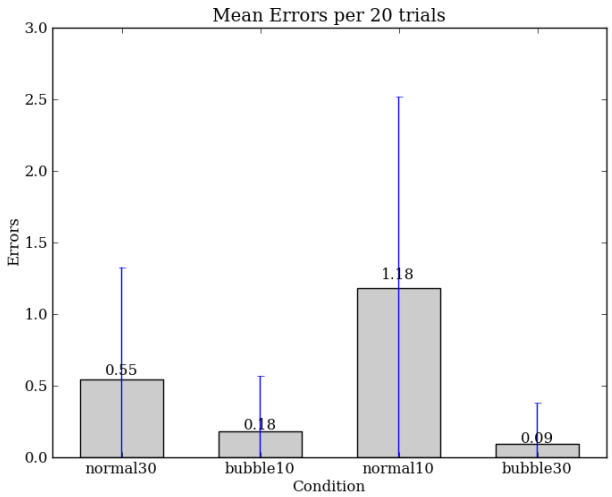
$$\sigma = \sqrt{\frac{\sum (X_i - \mu)^2}{N}}$$

Standard Deviation


1200
1000
800
600
400
200
0
Movement Time (milliseconds)
803
796
1129
723
normal30
bubble10
normal10
bubble30
Condition
What's missing from this bar chart?


Mean Movement Times (error bars show 1 St Dev)
1600
1400
1200
1000
800
600
400
200
0
Movement Time (milliseconds)
803
796
1129
723
normal30
bubble10
normal10
bubble30
Condition

Descriptive Statistics for Error



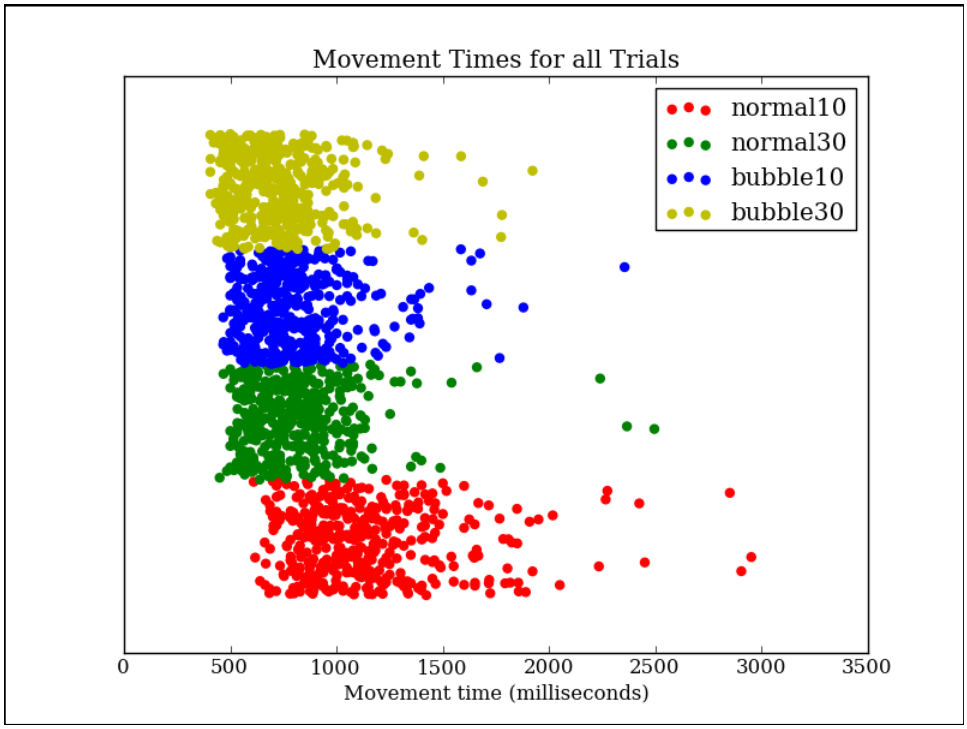
Understanding Your Data

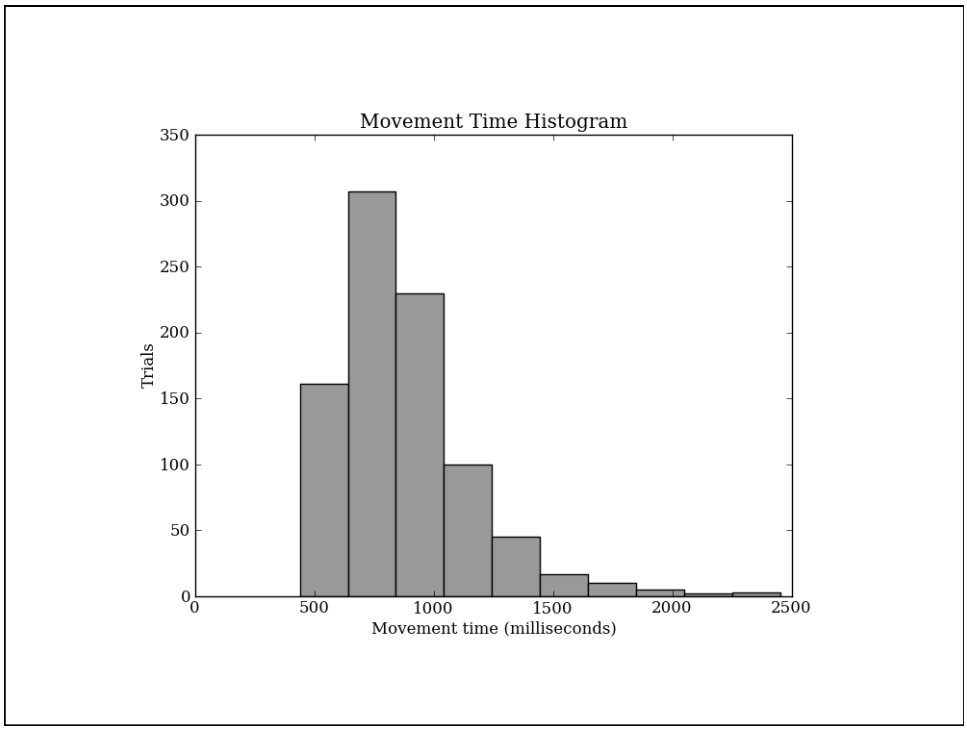
Exploratory Data Analysis (EDA):

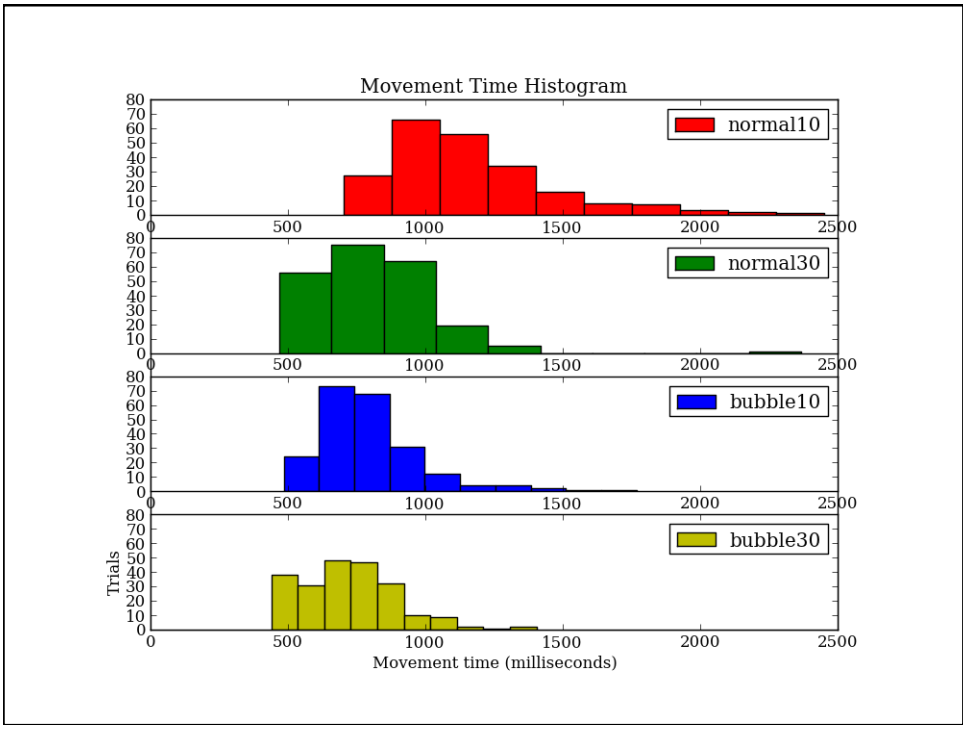
Look at your data from different perspectives to get better intuition for it.

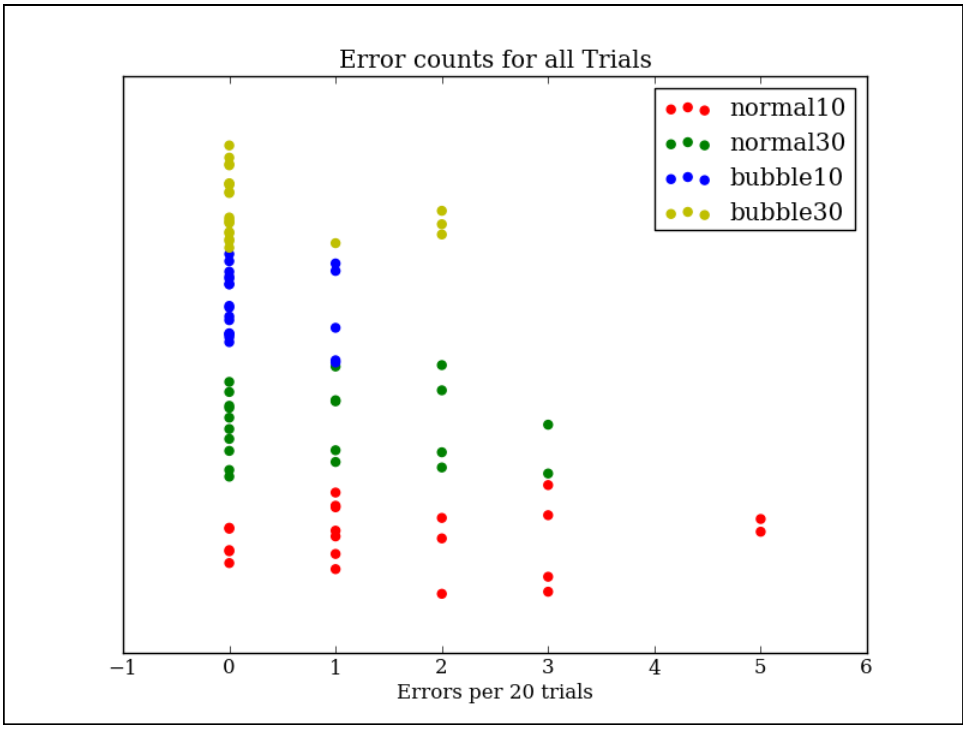
Show the raw data!

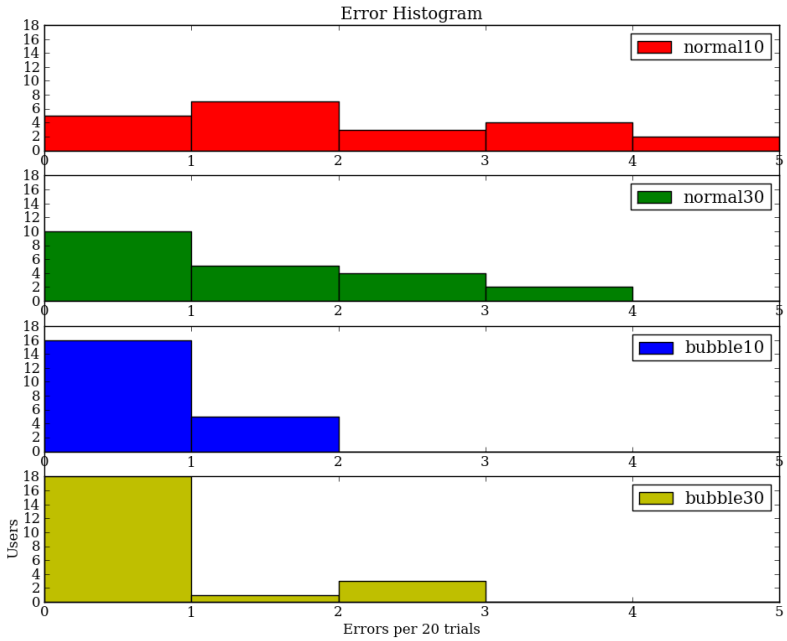
Use different visualizations: Histograms, scatterplots, box plots, …


Movement Times for all Trials
normal10
normal30
bubble10
bubble30
0
500
1000
1500
2000
2500
3000
3500
Movement time (milliseconds)


Movement Time Histogram
Trials
350
300
250
200
150
100
50
0
0
500
1000
1500
2000
2500
Movement time (milliseconds)


Movement Time Histogram
normal10
normal30
bubble10
bubble30
Trials
Movement time (milliseconds)


Error counts for all Trials
normal10
normal30
bubble10
bubble30
Errors per 20 trials



Median vs. Mean

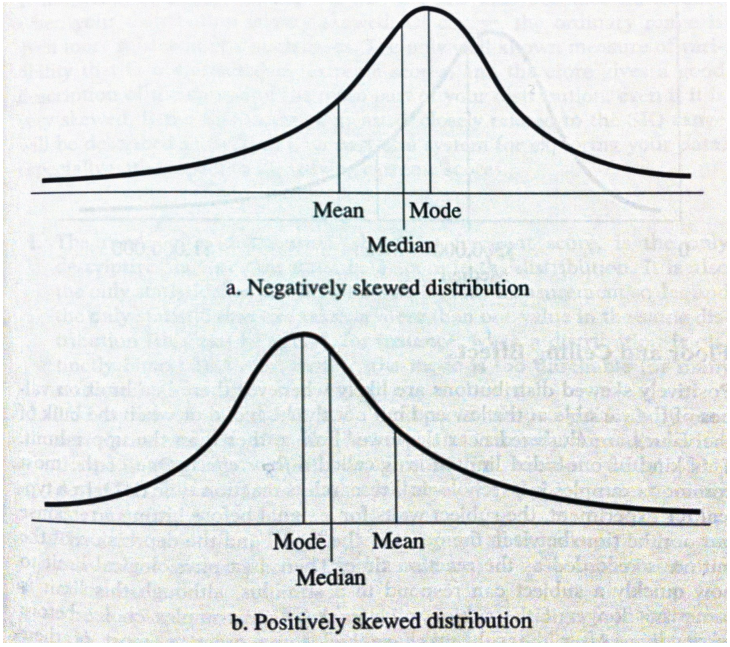
For normal distribution, median = mean

Most data is fitted to normal distribution so median and mean may differ

When data has outliers median more robust

Many data sets gathered online are strongly skewed (they exhibit **power law distributions** - "long tails")

Outliers pull the mean to the right/left
(mean of true power law distribution = ∞)



Power Law Distributions

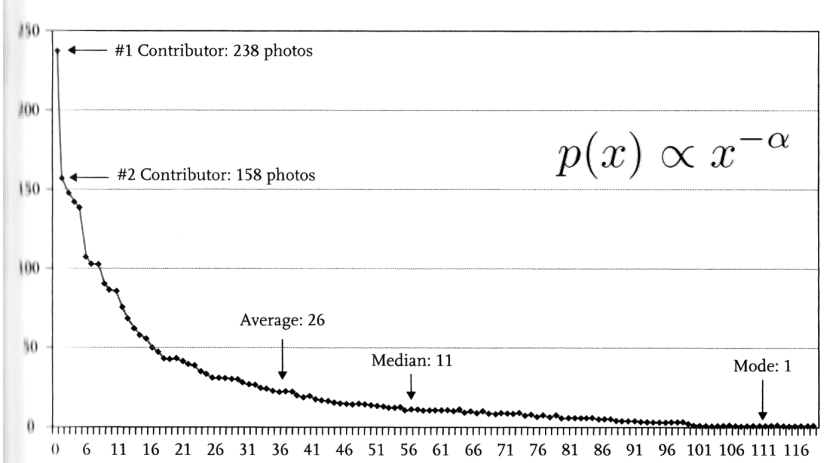


Figure 5-1: The distribution of photographers contributing photos of the 2005 Coney Island Mermaid Parade.

From C. Shirky, Here Comes Everybody

Cleaning Data

Don't discard data just because it doesn't fit your expectation! Maybe your assumptions were wrong.

In online experiments, discarding extreme outliers can make sense if you believe they reflect users not following normal task protocol (e.g., multitasking in a reaction-time study)

Effect Sizes: Time

Normal vs. Bubble cursor at target size 10:
1129ms vs. 796ms: Bubble cursor 30% faster

Normal vs. Bubble cursor at target size 30:
803ms vs. 723ms: Bubble cursor 10% faster

Target size for normal cursor:
1129ms vs 803ms: Larger targets 29% faster

Target size for Bubble cursor:
796ms vs. 723ms: Larger targets 9% faster

Effect Sizes: Time

Descriptive Statistics			
Factor	*Group*	*Sample size*	*Mean*
CURSOR x SIZE	*bubble x 10*	420	796.21905
CURSOR x SIZE	*bubble x 30*	440	723.03864
CURSOR x SIZE	*normal x 10*	420	1,129.36667
CURSOR x SIZE	*normal x 30*	420	803.2381
CURSOR	*bubble*	860	758.77791
CURSOR	*normal*	840	966.30238
SIZE	*10*	840	962.79286
SIZE	*30*	860	762.20581

Effect Sizes: Error

Normal vs. Bubble cursor, target size 10:

1.67 vs. 0.24 Errors per 20 trials: 85% fewer errors! (6.95x)

Normal vs. Bubble cursor, target size 30:

0.90 vs. 0.02 Errors per 20 trials: 98% fewer errors!

Effect Sizes: Error

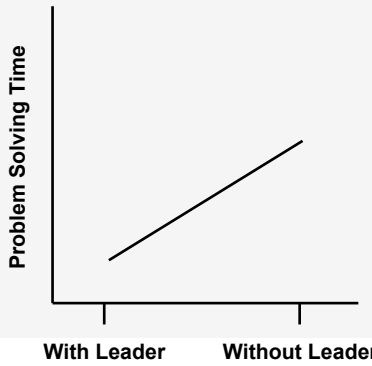
Descriptive Statistics

Factor	*Group*	*Sample size*	*Mean*
CURSOR x SIZE	*NORMAL x 10*	21	1.66667
CURSOR x SIZE	*NORMAL x 30*	21	0.90476
CURSOR x SIZE	*BUBBLE x 10*	21	0.2381
CURSOR x SIZE	*BUBBLE x 30*	22	0.31818
CURSOR	*NORMAL*	42	1.28571
CURSOR	*BUBBLE*	43	0.27907
SIZE	*10*	42	0.95238
SIZE	*30*	43	0.60465

Example of Interactions

Group problem solving

Independent variable: Leadership



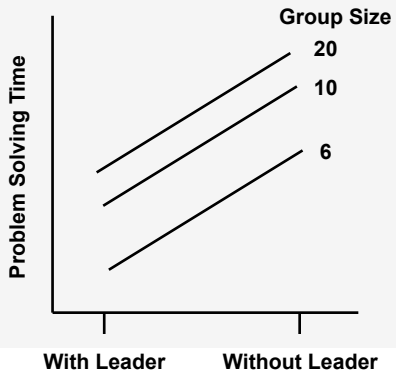
[from Martin 04]

Example of Interactions

Group problem solving

Independent variable: Leadership

Independent variable: Group size

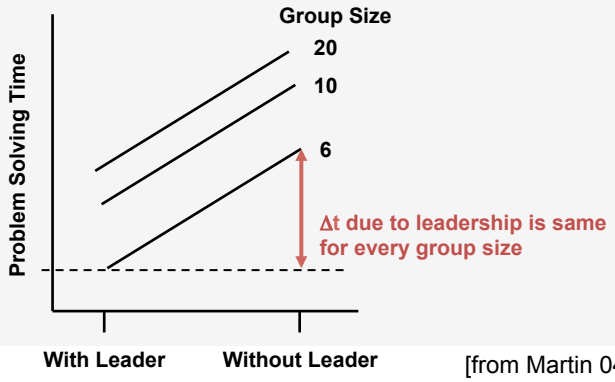


[from Martin 04]

Example of Interactions

Group problem solving

Change in time due to leadership is same regardless of group size



[from Martin 04]

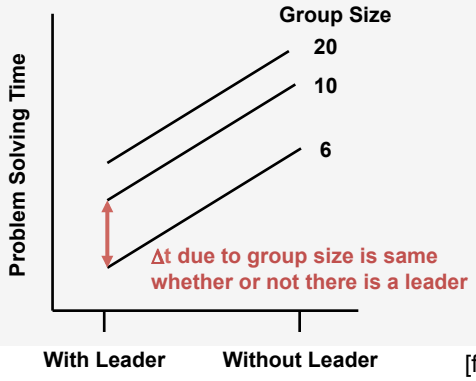
Example of Interactions

Group problem solving

Change in time due to leadership is same regardless of group size

Change in time due to group size is same regardless of leadership

Independent variables do not interact



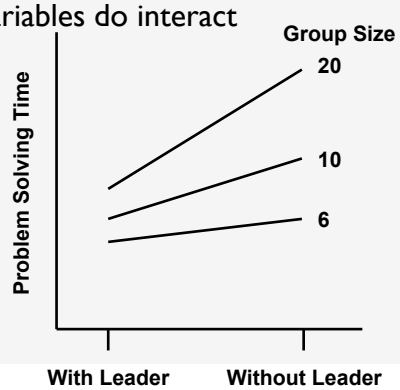
[from Martin 04]

Example of Interactions

Multiple IVs effect DV non-additively

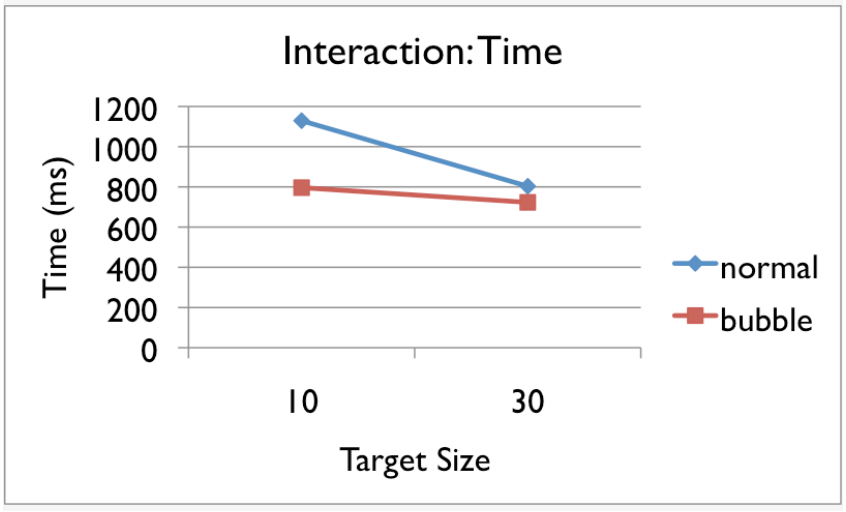
Change in time due to leadership differs with changes in group size

Independent variables do interact



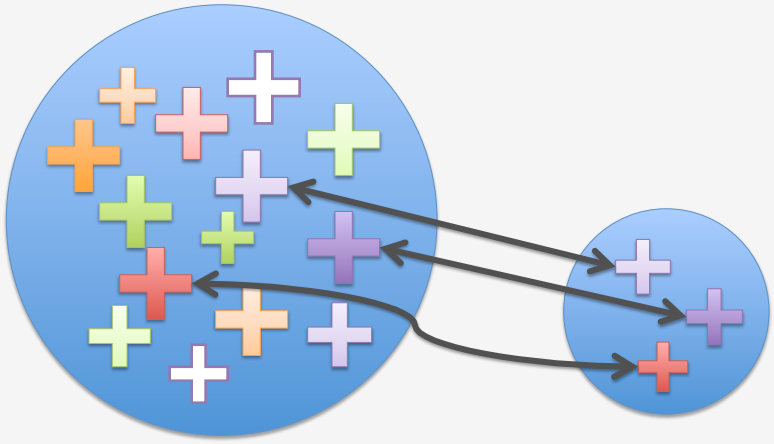
[from Martin 04]

Interactions



Interactions

Population versus Sample



Are the Results Meaningful?

Hypothesis testing

Hypothesis: Manipulation of IV effects DV in some way
Null hypothesis: Manipulation of IV has no effect on DV
Null hypothesis assumed true unless statistics allow us to reject it

Statistical significance (p value)

Likelihood that results are due to chance variation
$p < 0.05$ usually considered significant (Sometimes $p < 0.01$)
Means that < 5% chance that null hypothesis is true

Statistical tests

T-test (1 factor, 2 levels)
Correlation
ANOVA (1 factor, > 2 levels, multiple factors)
MANOVA (> 1 dependent variable)

Explaining Psychological Statistics
Barry H. Cohen