Controlled Experimentation

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DSC 96

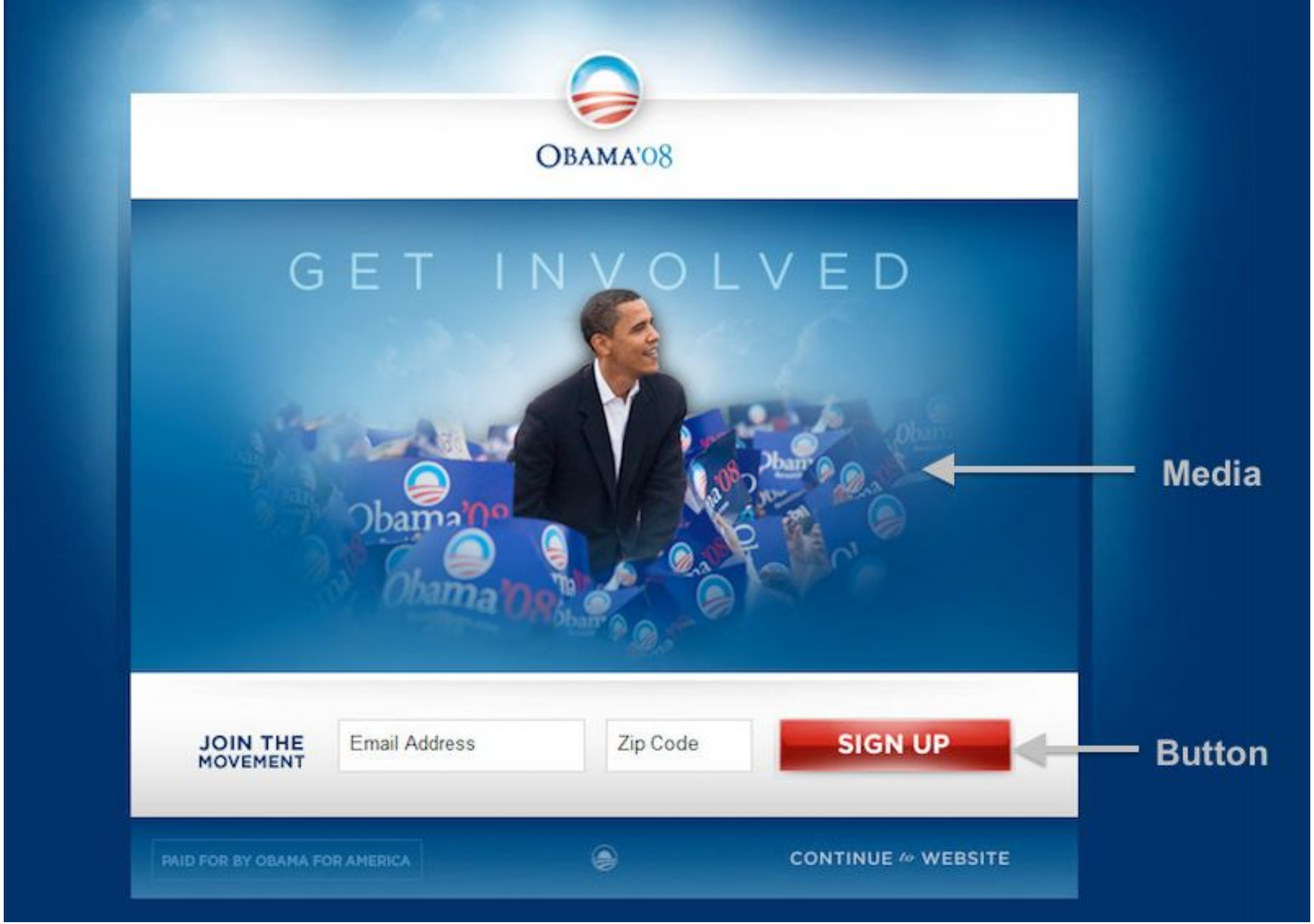
In the 1700s, a British ship's captain observed the lack of scurvy among sailors serving on the naval ships of Mediterranean countries, where citrus fruit was part of their rations.

He then gave half his crew limes (the Treatment group) while the other half (the Control group) continued with their regular diet.

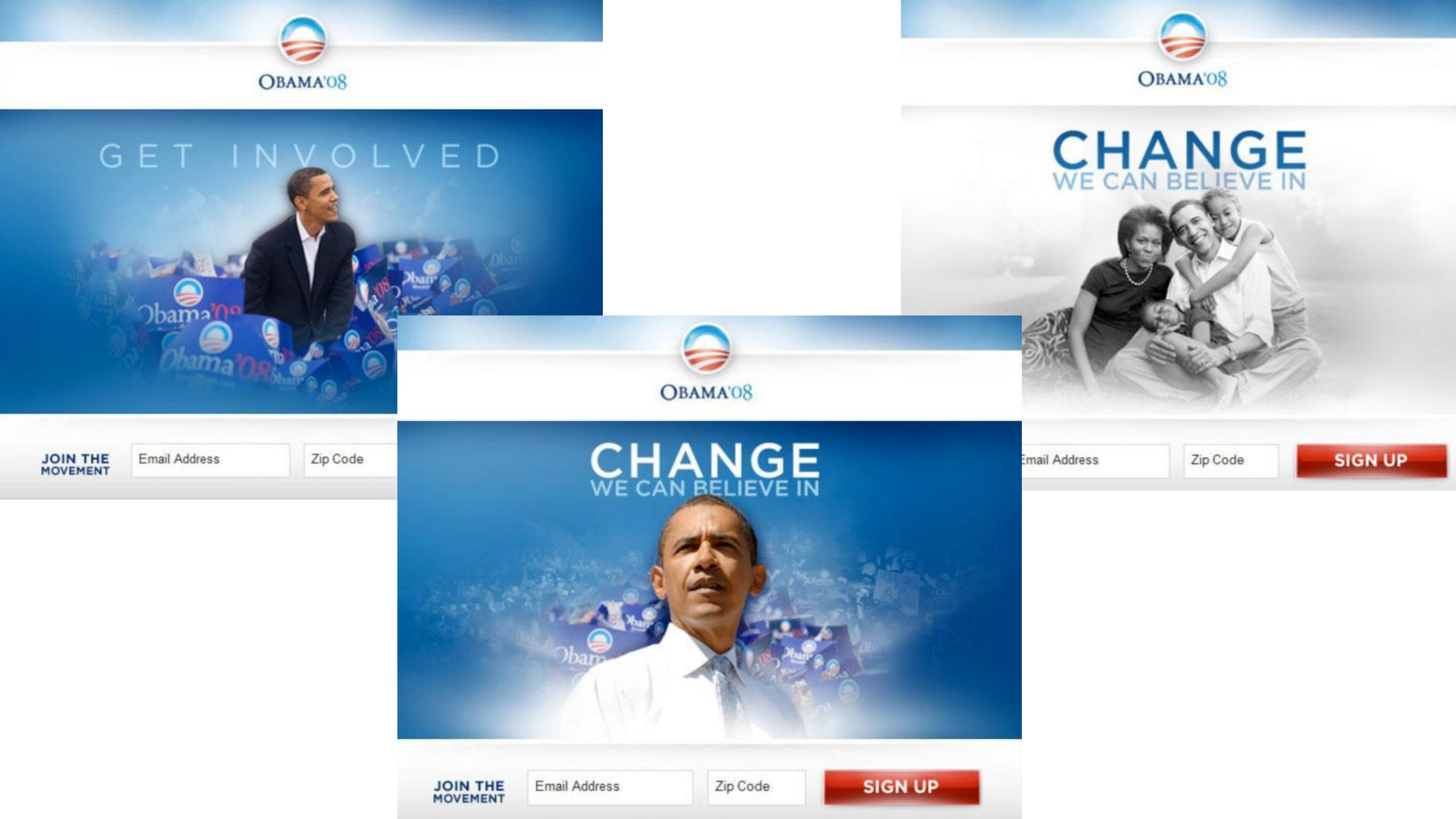
Despite much grumbling among the crew in the Treatment group, the experiment was a success, showing that consuming limes prevented scurvy.

While the captain did not realize that scurvy is a consequence of vitamin C deficiency, and that limes are rich in vitamin C, the intervention worked.

British sailors eventually were compelled to consume citrus fruit regularly, a practice that gave rise to the still-popular label limeys



https://blog.optimizely.com/2010/11/29/how-obama-raised-60-million-by-running-a-simple-experiment/


OBAMA'08
GET INVOLVED
JOIN THE MOVEMENT
Email Address
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OBAMA'08
CHANGE
WE CAN BELIEVE IN
Email Address
Zip Code
SIGN UP
OBAMA'08
CHANGE
WE CAN BELIEVE IN
JOIN THE MOVEMENT
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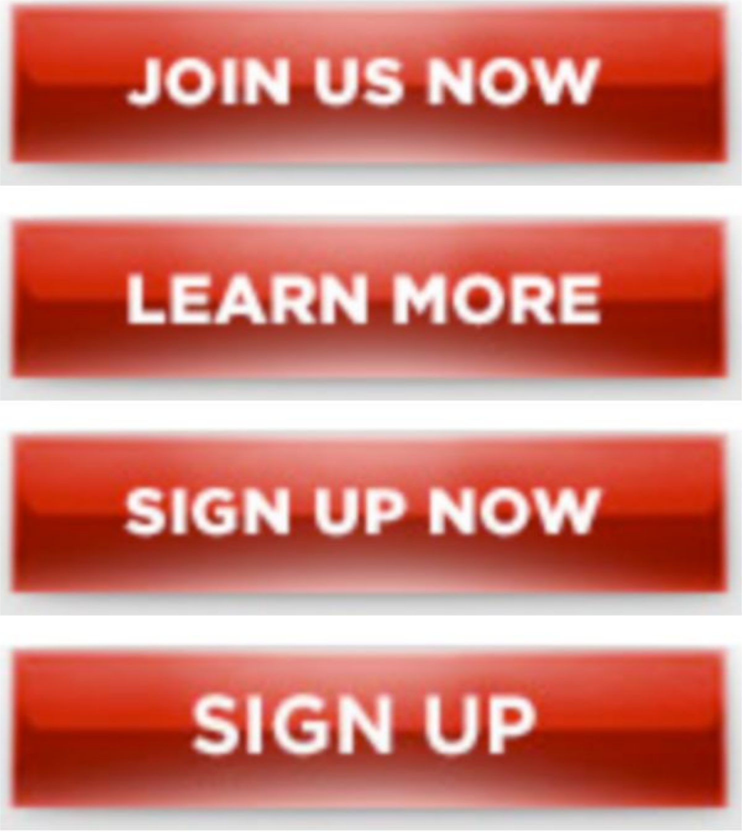
Zip Code
SIGN UP

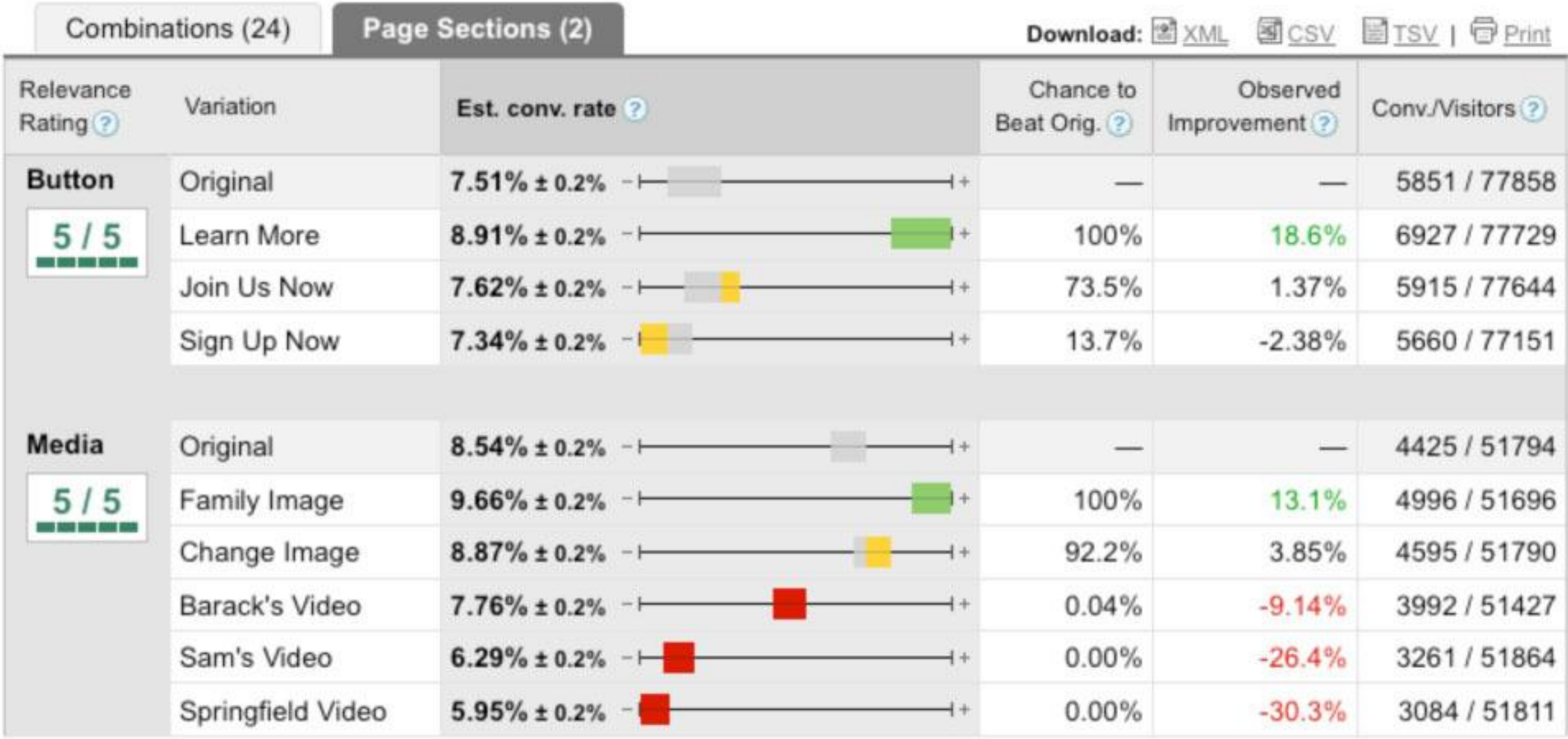
Button Variations



What would you choose?

The fewer the facts, the stronger the opinion

– Arnold Glasow



Relevance Rating ?	Variation	Est. conv. rate ?	Chance to Beat Orig. ?	Observed Improvement ?	Conv./Visitors ?
Button 5 / 5	Original	**7.51%** ± 0.2%	—	—	5851 / 77858
	Learn More	**8.91%** ± 0.2%	100%	18.6%	6927 / 77729
	Join Us Now	**7.62%** ± 0.2%	73.5%	1.37%	5915 / 77644
	Sign Up Now	**7.34%** ± 0.2%	13.7%	-2.38%	5660 / 77151
Media 5 / 5	Original	**8.54%** ± 0.2%	—	—	4425 / 51794
	Family Image	**9.66%** ± 0.2%	100%	13.1%	4996 / 51696
	Change Image	**8.87%** ± 0.2%	92.2%	3.85%	4595 / 51790
	Barack's Video	**7.76%** ± 0.2%	0.04%	-9.14%	3992 / 51427
	Sam's Video	**6.29%** ± 0.2%	0.00%	-26.4%	3261 / 51864
	Springfield Video	**5.95%** ± 0.2%	0.00%	-30.3%	3084 / 51811

Results

Running a different image and button provided:

- $60M in additional donations
- 2.8M additional email addresses
- 200k additional volunteers

A/B test results are often surprising!

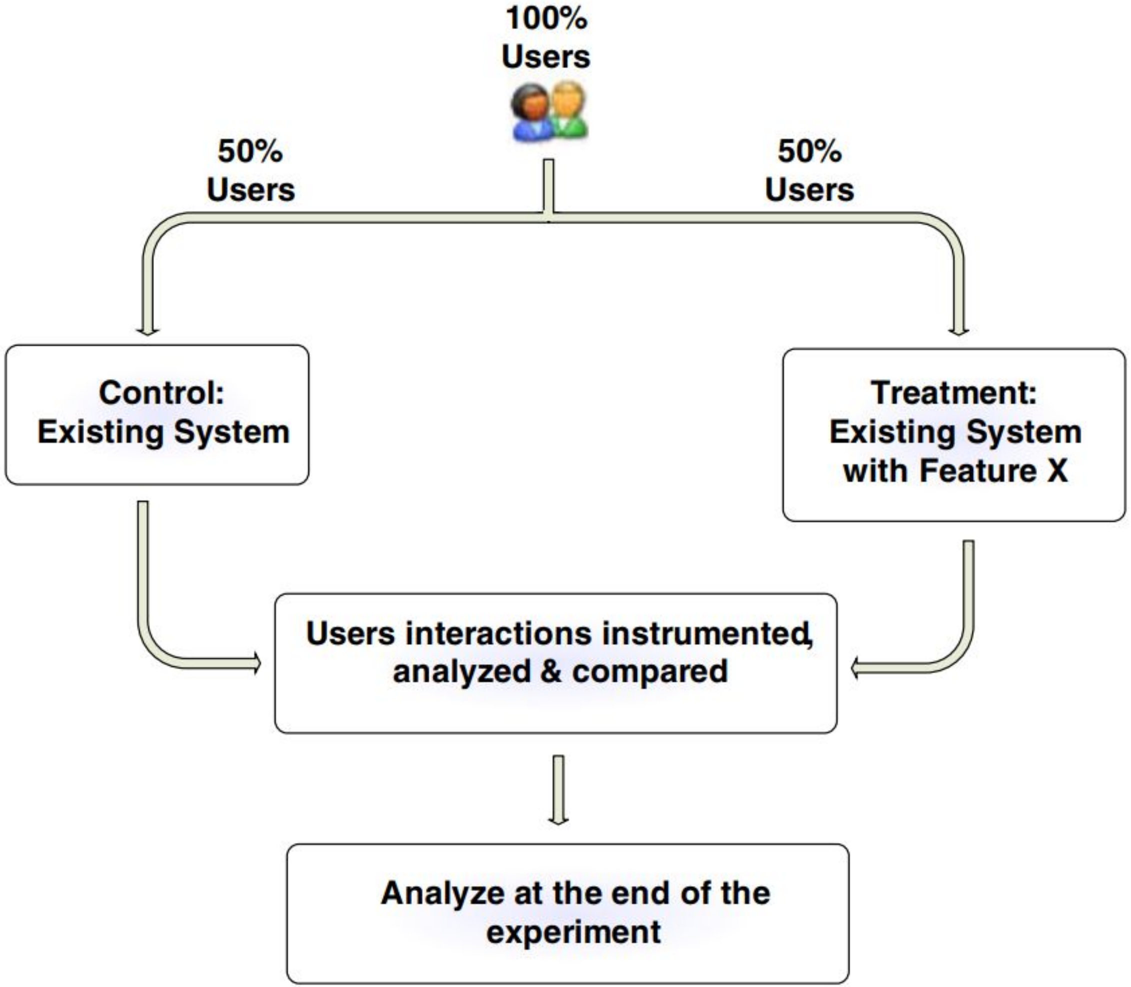
Experimenting on the Web

The web provides an unprecedented opportunity to evaluate ideas quickly using controlled experiments.

Also called randomized experiments, A/B tests (and their generalizations), split tests, Control/Treatment tests, MultiVariable Tests.

Controlled experiments embody the best scientific design for establishing a causal relationship between changes and their influence on user-observable behavior.

Experience indicates that significant learning and return-on-investment are seen when development teams listen to their customers, not to the highest paid person’s opinion.



100%
Users

50%
Users

50%
Users

Control:
Existing System

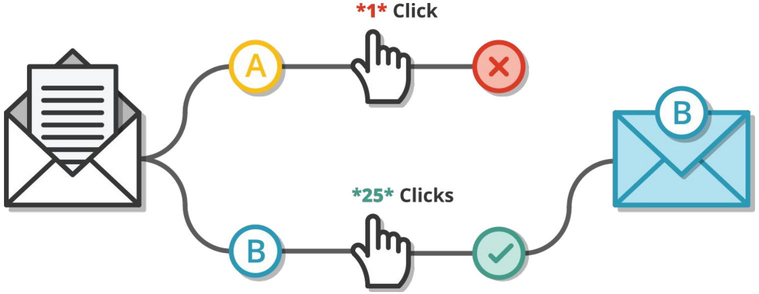
Treatment:
Existing System
with Feature X

Users interactions instrumented,
analyzed & compared

Analyze at the end of the
experiment

A/B tests

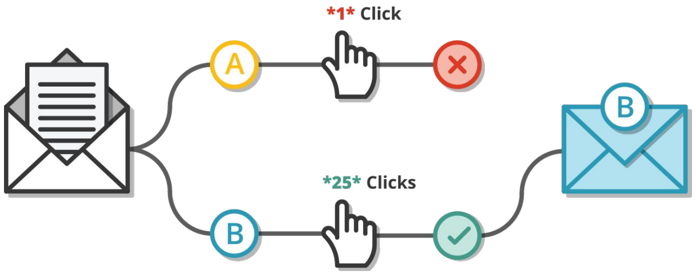
- Email A and B: Binary outcomes
    - 0, 0, 1, 1, 0, 1, 0, 0, …
    - 0, 0, 1, 0, 0, 0, 0, 1, …



- Diet A and B: weight
    - 32, 28, 27, 33, 38, 32, 31, …
    - 30, 26, 28, 34, 27, 33, 30, …

- How do we deal with these problems?

A/B test: binary outcomes



- Email 1: n_1 = 605, clicks: c_1 = 351
- Email 2: n_2 = 585, clicks: c_2 = 123
- Click per email: p_1 = 0.58 , p_2 = 0.21
- Is there enough evidence that Email 1 is better than email 2?
- Numbers are large (>100) so we can approximate with a Gaussian
- The null hypothesis is $p_1 = p_2$, we can calculate
- $p = (c_1 + c_2) / (n_1 + n_2)$: the mean click rate in the null hypothesis
- $\sigma^2 = p(1-p)$: the variance of the outcome
- $$t = \frac{\hat{p}_1 - \hat{p}_2}{\sqrt{\sigma^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$
- If t>1.96, they are actually different (with 95% confidence)

A/B test: real values

- Diet 1: n_1 = 220, average: μ_1 = 32
- Diet 2: n_2 = 189, average: μ_2 = 30
- Is there enough evidence that Diet 1 is more energetic than Diet 2?
- Numbers are large (>100) so we can approximate with a Gaussian
- The null hypothesis is $\mu_1 = \mu_2$, we can calculate
- σ^2 the variance of the outcome metric (more complicate to derive, but can be calculated from data)
-
- If t>1.96, they are actually different (with 95% confidence)

$$t = \frac{\hat{\mu}_1 - \hat{\mu}_2}{\sqrt{\left(\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}\right)}}$$

Minimum sample size

$$n = 16\sigma^2/\Delta^2$$

σ^2 is the variance of the outcome metric (in case of binary outcome, p(1-p))

Δ is the sensitivity (amount you want to detect) at 80% power

n is the sample size ($n = n_1+n_2$)

$$\Delta = \hat{\mu}_1 - \hat{\mu}_2$$

$$\Delta = \hat{p}_1 - \hat{p}_2$$

Data ***Science***

“A man conducting a gee-whiz science show with fifty thousand dollars’ worth of Frankenstein equipment is not doing anything scientific if he knows beforehand what the results of his efforts are going to be. A motorcycle mechanic, on the other hand, who honks the horn to see if the battery works is informally conducting a true scientific experiment. He is testing a hypothesis by putting the question to nature.”

- Zen and the Art of Motorcycle Maintenance