Stat 200 Presentation

Clay Olsen, Gulzina Kuttubekova, Meltem Ozcan, Zach Horton

3 December, 2019

University of California, Santa Cruz

Table of contents

Statistical Analysis and the Illusion of Objectivity

J.O. Berger & D.A. Berry (1988), *American Scientist*

Subjectivity and Scientific Analysis

Subjectivity and Scientific Analysis

- Science “should” be free from subjective input
- Can science actually be objective?

Subjectivity and Scientific Analysis

- Science “should” be free from subjective input
- Can science actually be objective?

- **Subjective science is not bad**

Subjectivity and Scientific Analysis

“Acknowledging the role of subjectivity in the interpretation of data could open the way for more accurate and flexible statistical judgments”

Subjectivity and Scientific Analysis

"Acknowledging the role of subjectivity in the interpretation of data could open the way for more accurate and flexible statistical judgments"

A core argument between Bayesians and Frequentists

Case Study: Vitamin C

Case Study Details

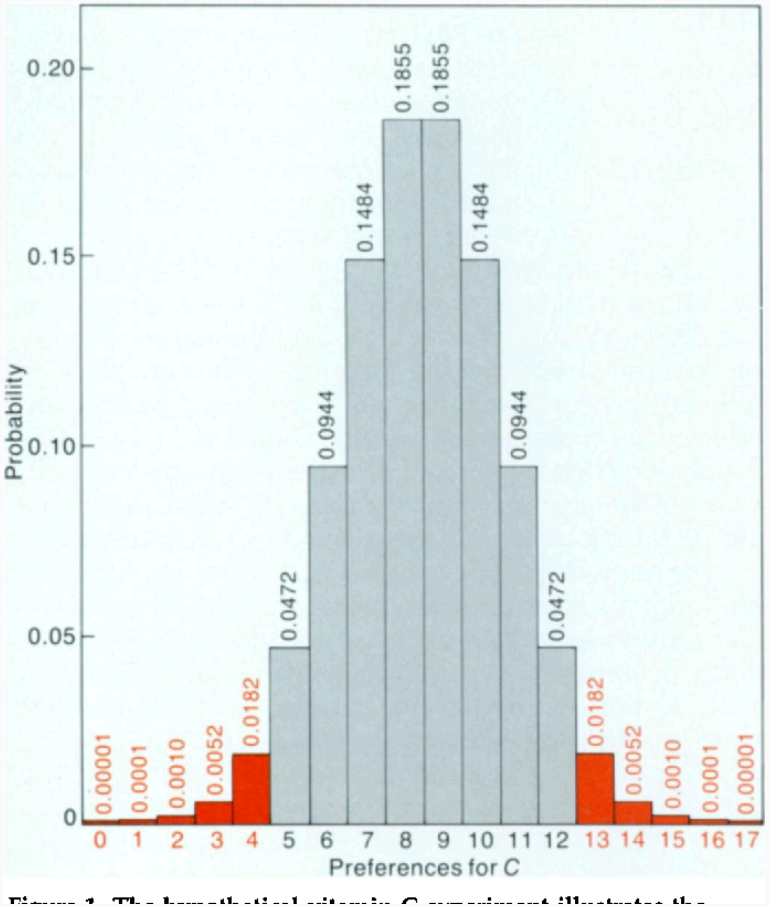
- H_0: Vitamin C has the same effect on the common cold as the placebo.
- H_A: Vitamin C has a different effect than the placebo.
- Design: 17 matched pairs of subjects randomly assigned to take vitamin C or a placebo (P)
- Outcome: Vitamin C better than Placebo in 13 pairs, Placebo better than Vitamin C in 4 pairs (13 Successes, 4 Failures).

Standard Approach

- Binomial model ($m = 17$)
- $H_0 : p = \frac{1}{2}, H_a : p \neq \frac{1}{2}$

P-value = Probability of obtaining replicate results **as or more extreme** than what was observed

$P\text{-}value = \sum_x p(x) : p(x) \leq 0.0182$

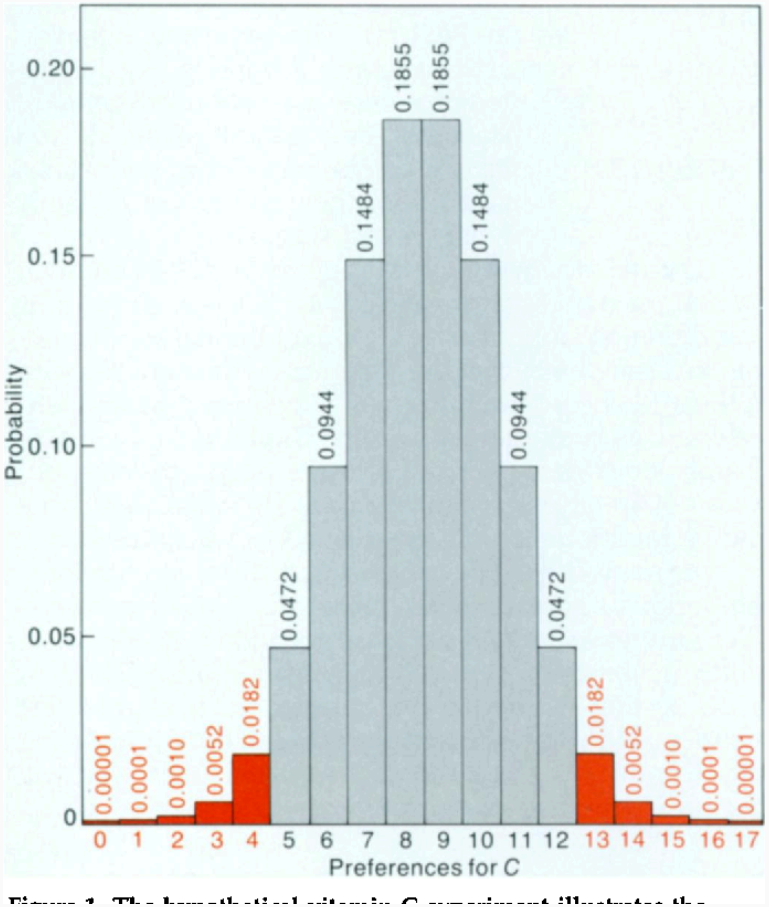


Standard Approach

- Binomial model ($m = 17$)
- $H_0 : p = \frac{1}{2}, H_a : p \neq \frac{1}{2}$

P-value = Probability of obtaining replicate results **as or more extreme** than what was observed

$P\text{-}value = \sum_x p(x) : p(x) \leq 0.0182$



Result: Assuming the null hypothesis is true, the probability of obtaining replicate results as or more extreme than what was observed is 0.049, which is smaller than 0.05, making the null hypothesis suspect.

Bayesian Approach

- Same model: Binomial model ($m = 17$)
- With the same hypothesis: $H_0 : p = \frac{1}{2}$, $H_a : p \neq \frac{1}{2}$
- Requires p_o: prior probability, chosen by practitioner
- A p_o = 0.6 corresponds prior belief that vitamin C will be marginally more effective than the placebo

Bayesian Approach

- Same model: Binomial model ($m = 17$)
- With the same hypothesis: $H_0 : p = \frac{1}{2}$, $H_a : p \neq \frac{1}{2}$
- Requires p_o: prior probability, chosen by practitioner
- A p_o = 0.6 corresponds prior belief that vitamin C will be marginally more effective than the placebo

Result: The probability that H_0 is true given the observed data is 0.41

Interpretation and Subjectivity

The Bayesian result is clear, easy to interpret. The standard result is not, and may even be misleading.

"consumers of data WANT a final probability; they want to know how probable it is that the hypothesis is true in light of the data. Since standard statistics cannot answer this question, and indeed gives no guidance in translating P-values into an answer, it is difficult to blame consumers for taking the number provided – the P-value – and interpreting it as an answer."

Interpretation and Subjectivity

The Bayesian result is clear, easy to interpret. The standard result is not, and may even be misleading.

"consumers of data WANT a final probability; they want to know how probable it is that the hypothesis is true in light of the data. Since standard statistics cannot answer this question, and indeed gives no guidance in translating P-values into an answer, it is difficult to blame consumers for taking the number provided – the P-value – and interpreting it as an answer."

P-values are an indirect measure of a desired underlying quantity. Thus, interpreting them is a form of subjective analysis. Not to mention they are often misinterpreted or misused, the worst kind of subjectivity.

P-values and Researcher Intentions

Alternative Standard Approach

- Negative-binomial model ($m = 4$)
- $H_0 : p = \frac{1}{2}, H_a : p \neq \frac{1}{2}$

P-value = Probability of obtaining replicate results **as or more extreme** than what was observed

P-value = $\sum_x p(x) : p(x) \leq 0.0085$

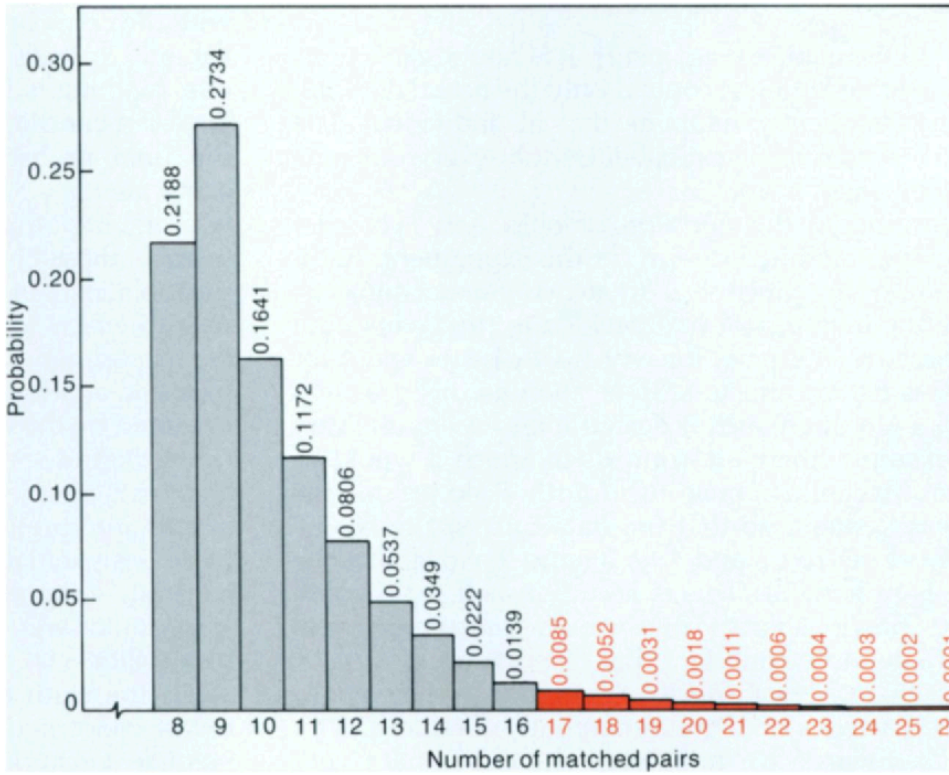


Figure 2. The effect of the intentions of the investigator on the *P*-value is demonstrat

Alternative Standard Approach

- Negative-binomial model ($m = 4$)
- $H_0 : p = \frac{1}{2}, H_a : p \neq \frac{1}{2}$

P-value = Probability of obtaining replicate results **as or more extreme** than what was observed

$P\text{-value} = \sum_x p(x) : p(x) \leq 0.0085$

Result: P-value $= 0.021$ (was 0.049).

Problem: Same data, different p-value

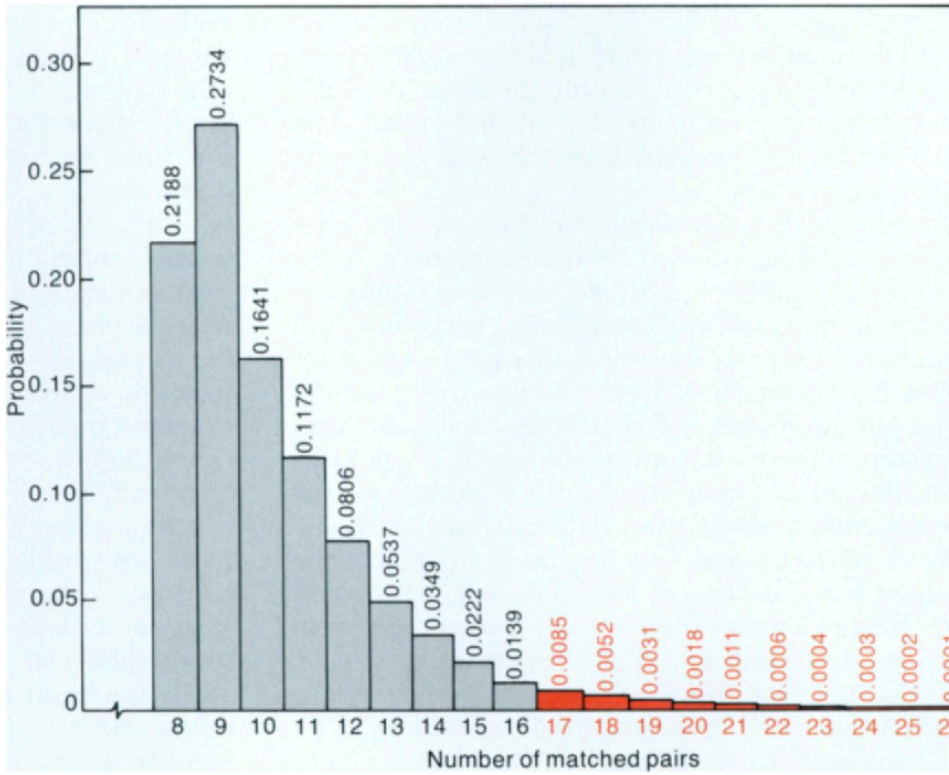


Figure 2. The effect of the intentions of the investigator on the *P*-value is demonstrat

Alternative Standard Approach

- Negative-binomial model ($m = 4$)
- $H_0 : p = \frac{1}{2}, H_a : p \neq \frac{1}{2}$

P-value = Probability of obtaining replicate results **as or more extreme** than what was observed

$P\text{-value} = \sum_x p(x) : p(x) \leq 0.0085$

Result: P-value $= 0.021$ (was 0.049).
Problem: Same data, different p-value

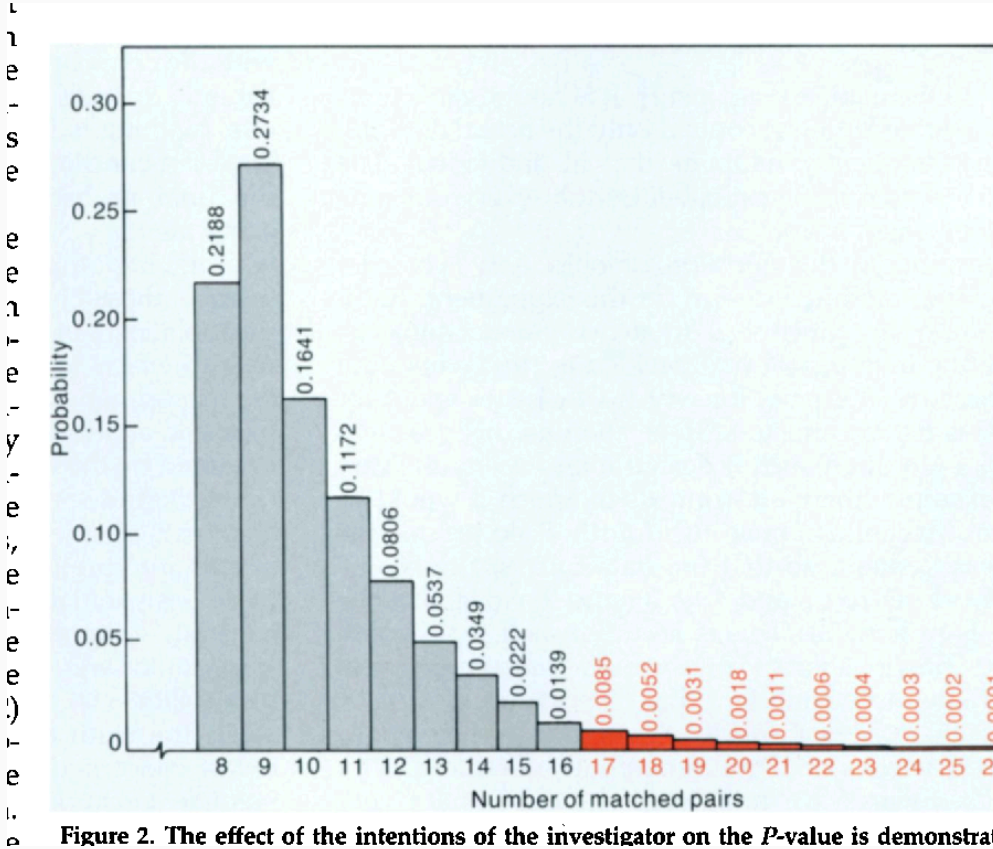


Figure 2. The effect of the intentions of the investigator on the *P*-value is demonstra

P-values are influenced by researcher intention

As or more extreme

- Bayesian subjectivity is clearly given via the prior
- Bayesian probabilities do not depend on unobserved data
- Frequentist subjectivity is implicit in ”as or more extreme”

As or more extreme

- Bayesian subjectivity is clearly given via the prior
- Bayesian probabilities do not depend on unobserved data
- Frequentist subjectivity is implicit in ”as or more extreme”

- **P-values depend on researcher intentions**
- **Bayesian probabilities depend on analyst intentions/beliefs**

`subjectivity is inevitable`

The Role of Subjectivity

The Role of Subjectivity : Conclusions

- **Objectivity is not generally possible in statistics**
- Advantages of being upfront with subjectivity:
  - Clear interpretation of results
  - Transparent specification of subjectivity
  - Many other benefits
- Embracing the need for subjectivity through Bayesian analysis can lead to more powerful, flexible, and understandable analyses of data.