9.1
Significance Tests:
The Basics
(Day 1)

vocab

examples

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Objectives

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How good can you shoot?

A basketball player claims to make 80% of the free throws that he attempts. We think he might be exaggerating. To test this claim, we'll ask him to shoot some free throws...

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The logic of statistical tests

Our virtual basketball player in the previous Activity claimed to be an 80% free-throw shooter. There are two options:

1. He does, in fact make 80% of his shots.
2. He is overestimating and he makes less than 80% of his shots.

Suppose that he shoots 50 free throws and makes 32 of them.

$\hat{p}$ = .64

What can we conclude?

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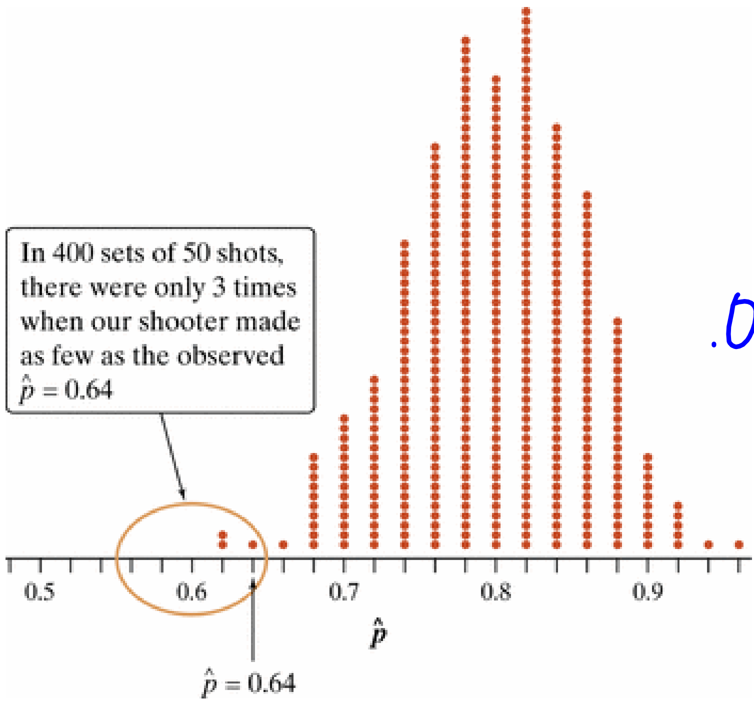
The logic of statistical tests



.0075

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Null Hypothesis

A claim of no difference

Notation: H_O

Ex/ H_O: p = 0.8

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Alternative Hypothesis

The claim we hope or suspect to be true

Notation: H_a

Ex/ $H_a: p < 0.8$

*note: you MUST use parameters, not statistics!

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One Sided Alternative Hypothesis

The alternative hypothesis is one-sided if it states that a parameter is larger than the null hypothesis value or if it states that the parameter is smaller than the null value.

Ex/ $H_a: p < 0.8$ or $H_a: p > 0.8$

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Two Sided Alternative Hypothesis

The alternative hypothesis is two-sided if it states that the parameter is different from the null hypothesis value (it could be either larger or smaller).

Ex/ H_a: $p \neq 0.8$

*note: Hypotheses are formed before collecting data. Use wording to help you decide, not the data!

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Practice #1

For each of the following settings, (a) describe the parameter of interest, and (b) state appropriate hypotheses for a significance test.

1. According to the Web site sleepdeprivation.com, 85% of teens are getting less than eight hours of sleep a night. Jannie wonders whether this result holds in her large high school. She asks an SRS of 100 students at the school how much sleep they get on a typical night. In all, 75 of the responders said less than 8 hours.

a) parameter - p - proportion of teens who get less than 8 hours of sleep at Jannie's HS

b) $H_0: p = .85$
$H_a: p \neq .85$

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Practice #2

For each of the following settings, (a) describe the parameter of interest, and (b) state appropriate hypotheses for a significance test.

2. As part of its 2010 census marketing campaign, the U.S. Census Bureau advertised "10 questions, 10 minutes—that's all it takes." On the census form itself, we read, "The U.S. Census Bureau estimates that, for the average household, this form will take about 10 minutes to complete, including the time for reviewing the instructions and answers." We suspect that the actual time it takes to complete the form may be longer than advertised. μ

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Practice #2

For each of the following settings, (a) describe the parameter of interest, and (b) state appropriate hypotheses for a significance test.

2. As part of its 2010 census marketing campaign, the U.S. Census Bureau advertised "10 questions, 10 minutes—that's all it takes." On the census form itself, we read, "The U.S. Census Bureau estimates that, for the average household, this form will take about 10 minutes to complete, including the time for reviewing the instructions and answers." We suspect that the actual time it takes to complete the form may be longer than advertised.

(a) parameter - μ, the amount of time it takes to complete the US census

(b) H_O: $\mu = 10$

H_a: $\mu > 10$

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P-Value

The probability, computed assuming H_0 is true, that the statistic (such as $\hat{p}$ or $\bar{x}$) would take a value as extreme as or more extreme than one actually observed is called the P-value of the test.

The smaller the P-value, the stronger the evidence against H_O provided by the data.

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In the Basketball Scenario...

The P-value is the conditional probability:

$P(\hat{p} \leq 0.64 \mid p = .80)$

The simulation showed that this was 3/400 = 0.0075

So if H_O is true , there's less than a 1 in 100 chance that the player would make as few as 32 out of 50 shots. This would give strong evidence against H_O and in favor of H_a.

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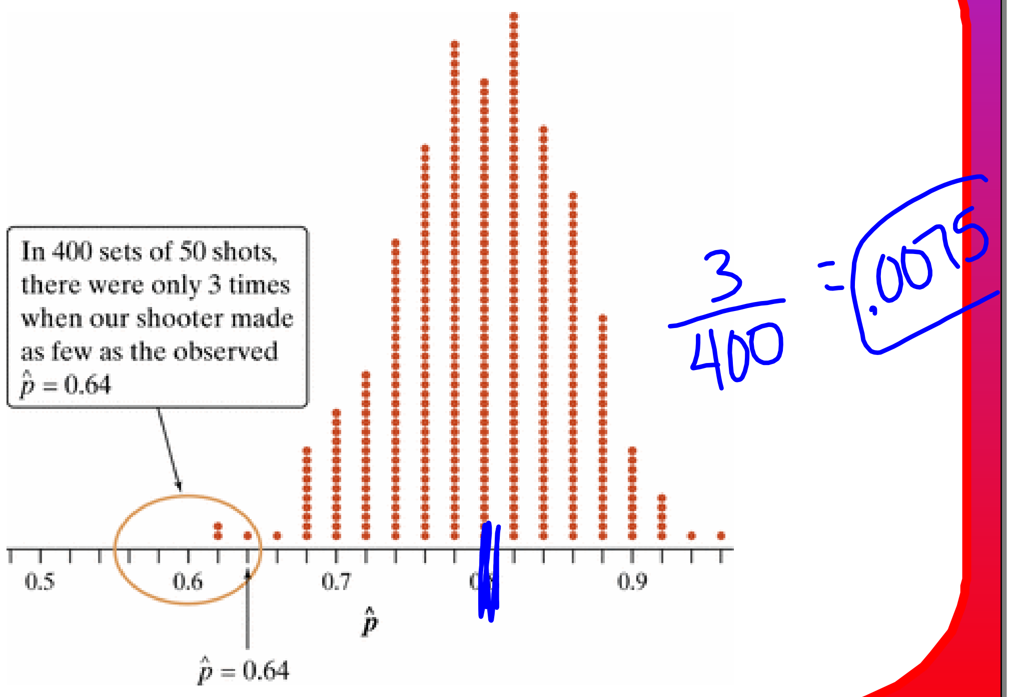
The logic of statistical tests



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Interpreting a P-Value

The probability of getting a sample result at least as extreme as the one we did if H_O were true.

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Golf Club

When Mike was testing a new 7-iron, the hypotheses were H_O: σ = 15 versus H_a: σ < 15 where σ = the true standard deviation of the distances Mike hits golf balls using the new 7-iron. Based on a sample of shots with the new 7-iron, the standard deviation was s_x = 13.9 yards. A significance test using the sample data produced a *P*-value of 0.28. Interpret the *P*-value in this context.

The probability of getting a sample st. dev. of 13.9 or less is .28 if H_0 is true that σ = 15

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Statistically Significant

If the P-value is smaller than alpha, we say that the data are statistically significant at level α. In that case, we reject the null hypothesis H_O and conclude that there is convincing evidence in favor of H_a

α

α

Must decide on α before data is collected.
Most common: α = 0.05

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Significance Test Conclusions

P-value < α → reject H_0 → conclude H_a (context)

P-value ≥ α → fail to reject H_0 → cannot conclude H_a (context)

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AP TIP

Always reject or fail to reject in context!

Never ACCEPT the null hypothesis!

Must link conclusion to P-value

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Better Batteries

A company has developed a new deluxe AAA battery that is supposed to last longer than its regular AAA battery. However, these new batteries are more expensive to produce, so the company would like to be convinced that they really do last longer. Based on years of experience, the company knows that its regular AAA batteries last for 30 hours of continuous use, on average. The company selects an SRS of 15 new batteries and uses them continuously until they are completely drained. A significance test is performed using the hypotheses

$H_O: \mu = 30$

$H_a: \mu > 30$

where μ is the true mean lifetime of the new deluxe AAA batteries. The resulting P-value is 0.0276.

What conclusion would you make for each of the following significance levels? Justify your answer.

(a) $\alpha = 0.05$ (b) $\alpha = 0.01$

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Better Batteries

$H_O: \mu = 30$

$H_a: \mu > 30$

P-value is 0.0276.

(a) $\alpha = 0.05$

.0276< .05 --> We reject that the mean battery life is 30 hours --> We conclude that the companies deluxe AAA batteries last longer than 30 hours, on average. The results are statistically significant at the 5% level.

(b) $\alpha = 0.01$

.0276 ≥ .01--> We fail to reject that the mean battery life is 30 hours --> We cannot conclude that the companies delux AAA batteries last longer than 30 hours, on average. The results are not statistically significant at the 1% level.

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Potato Chips

For his second semester project in AP Statistics, Zenon decided to investigate whether students at his school prefer name-brand potato chips to generic potato chips. After collecting data, Zenon performed a significance test using the hypotheses: $p = 0.5$ versus: $p > 0.5$ where p = the true proportion of students at his school who prefer name-brand chips. The resulting P-value was 0.074. What conclusion would you make at each of the following significance levels?

(a) $\alpha = 0.10$ (b) $\alpha = 0.05$

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(a) $\alpha = 0.10$

.074 < .10 --> We reject the null hypothesis that p = .5 --> We conclude that the true proportion of students who prefer name brand chips is larger than .5

The results are statistically significant at the 10% level.

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(b) $\alpha = 0.05$

.074 ≥ 0.05 --> We fail to reject the null hypothesis --> We cannot conclude that the true proportion of students who prefer name brand chips is larger than .5

The results are not statistically significant at the 5% level.

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