# ALPHA LEVELS, CRITICAL VALUES, AND P-VALUES...OH, MY

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Critical values, p-values, alpha level, hypothesis tests -

that's a lot of vocabulary.

But lucky for us, it's vocabulary that's all related.

We have a Null and an Alternative Hypothesis,

with our Alternative Hypothesis specifically

stating that there is a difference from some value specified

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in the Null Hypothesis statement.

This can be a difference in either direction, or a directional difference.

But how do we come up with a criteria of what

constitutes a significant difference?

This is where critical values, and p-values, and something

called our alpha level come into play.

Let's go ahead and take a look at our rancher's problem again

- the one with the cattle that he's given a high fat feed

diet for two months.

We know we have these parameters already: The Null and Alternative

Hypothesis, and a sample of 32 randomly selected steer.

At the end of the two months, the sample of 32 head

showed a weight gain of 16.4 pounds.

As luck would have it, the rancher was able to provide us

with the standard deviation of weight gain for his entire heard

- providing us with a standard deviation of the population,

or sigma, of 4.6 pounds.

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Now with all this information, we can perform a single sample z-test

to determine if our sample mean of 16.4 pounds of weight gain

is "different" from the Null of 15 pounds.

Here's what a visualization of the Null Hypothesis

looks like with our proposed mu - our Null Hypothesis value - in the center

of the distribution.

Now, all we need to do is establish at what point along this this distribution

will the sample mean value be considered "different" from our Null.

Now we're not thinking about OUR sample mean value yet

- we'll get there in a little bit.

Right now we're just trying to establish a value or values on this distribution

that we'll consider "different" from the Null.

In statistics, we have this basic game plan:

we can trun to what's called an alpha level, which

informs our critical values, which in turn is related

to the p-value of our statistical test.

Now, in most areas of statistical investigation,

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the alpha level is set at 0.05.

It basically says that we will say something is different from the Null

Hypothesis value if the likelihood of it happening by chance is 5% or less.

If we are simply looking for a difference from our Null value,

then that 5% is represented out here in our distribution - 2.5%

on the low end and 2.5% on the high end for a total of 5%.

Notice both tails have a possibility for our test -

so this would be considered a two-tailed hypothesis test.

Since we're using a z-test, and we know we're using the normal distribution,

can we find a z-statistic value that represents the lower 2.5%

and the upper 2.5%?

Well sure - we can use a z-table or we can use the qnorm() function in R.

The value of z that represents the lower 2.5% of the normal distribution is

-1.96 and the value of z that represents the upper value is 1.96.

These two values - the cut offs for our alpha level specific

to our statistical test - are known as critical values.

Notice also that our visualization has started

to use the values of the statical test we're using.

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Our mu - our center value - that represents

our Null value here is actually zero.

Now why are they "critical"?

Because a statistical finding that falls "beyond" these values

- father away from the center of the distribution in either direction

- will cause us to Reject our Null Hypothesis.

These values designate where - at this specific alpha level

- we would consider a finding to be different from the Null.

If we go through the mechanics and solve for our z-statistic,

with the following formula, we get a value of 1.72.

This value is NOT out past our critical values

- it is NOT in the critical region of our test distribution.

Now, if we want, we can even see what these actual raw weight difference

scores would be.

Now, what about this thing called p-value?

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Well, we know that our critical values, informed by our alpha level,

show us where 5% of our test distribution lies.

OUR sample mean had a raw score of 16.4, which

corresponded to a z-statistic of 1.72.

Now, the probability of finding a z-statistic value of 1.72 or higher

is 4.26% or as a proportion 0.0426.

But, our test actually asks for either possibility -

a z-value both above AND below the Null.

What if we got a z-value of -1.72?

Well it means that we see the same magnitude of difference,

just in the opposite direction.

And the probability of finding a z-value of -1.72 or lower is also 4.26%.

Taking both possibilities together gives us our p-value -

and we represent it as a proportion.

For our example, that's 0.0852.

And, does this p-value fall below our alpha level?

No.

Just like our z-statistic doesn't fall into the critical region.

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So how are these three concepts related?

Our alpha level is the starting point - it's

our concept for "difference" in our chosen test.

Our alpha level (and our statistical test)

tell us what our critical value of our statistic will be

- what the cut off for "difference" is.

Any statistic that is past this critical value,

and we Reject our Null Hypothesis.

And finally, there's our p-value, and it's

related to both, as it tells us the proportion of finding a test

statistic from our chosen test purely by chance.

Smaller than our alpha and again, we Reject our Null.

And all of this plays nicely into Hypothesis Testing.

Remember our steps?

Set up our Null and Alternative Hypotheses.

Gather and/or analyze our data.

And then make our conclusion: Reject or Fail to Reject our Null Hypothesis.

There's actually a step nestled in right here,

where we decide what our criteria of difference - what our alpha level

- will be.

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# Comprehension Check

1. A medical researcher compares a new treatment for poison ivy against a traditional ointment. He finds that the new treatment significantly reduces itching, with a p-value of 0.047.

(1/1 point)

What does the p-value mean in this context?

- (selected) It is the likelihood of observing this reduction in itching if there really is no difference between the two treatments ✔
- It is the chance that the new treatment is effective.
- It is our level of confidence in the difference between the two treatments.
- It is the proportion of new treatments that were found to be more effective than traditional ointments.

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2. Aviation experts fear that pilots are being asked to fly longer than is recommended by national guidelines. Current FAA regulations for domestic flights generally limit pilots to eight hours of flight time during a 24-hour period. FAA administrators conduct an analysis using a large sample of flight records for domestic flights in the past year.

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(1/1 point)

2a. What are the null and alternative hypotheses for this test?

- (selected) $Ho : \mu \leq 8\ hours$, and $Ha : \mu > 8\ hours$ ✔
- $Ho : \mu \leq 8\ hours$, and $Ha : \mu < 8\ hours$
- $Ho : \mu = 8\ hours$, and $Ha : \mu \neq 8\ hours$
- $Ho : \mu \neq 8\ hours$, and $Ha : \mu = 8\ hours$

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(1/1 point)

2b. If the FAA administrators want to be 95% confident in the result of their hypothesis test, what value of $\alpha$ should they set?

- $\alpha = 0.001$
- $\alpha = 0.10$
- $\alpha = 0.025$
- $\alpha = 0.05$ ✔

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(1/1 point)

2c. Identify the critical z-value(s) for this problem.

- $z = 2.31$
- $z = -1.96$
- $z = 1.65$ ✔
- $z = \pm 1.96$

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(1/1 point)

2d. The average flight time for the pilots is found to be 8.12 hours. The standard deviation reported by the FAA is 0.72 hours, and there were 81 pilots in the sample. What is the z-statistic for this hypothesis test?

- $z = 0.15$
- $z = 1.10$
- $z = 1.50$
- $z = -0.15$

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2e. Is the z-statistic in the critical region?

- Yes
- No
- Cannot be determined

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(1/1 point)

2f. What should be the conclusion of this test?

- Reject the null hypothesis.
- Fail to reject the null hypothesis.

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