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Chapter 23 – Inferences About Means

Coffee Machines

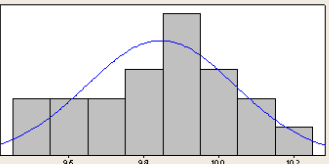

- A coffee machine dispenses coffee into paper cups. You're supposed to get 10 ounces of coffee, but the amount varies slightly from cup to cup. Here are the amounts measured in a random sample of 20 cups. Is there evidence that the machine is shortchanging customers?

9.9	9.7	10.0	10.1	9.9	9.6	9.8	9.8
10.0	9.5	9.7	10.1	9.9	9.6	10.2	9.8
10.0	9.9	9.5	9.9				

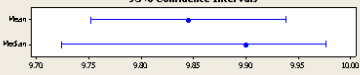
- Enter the data in Minitab, C1. Report preliminary findings.

Just Checking...

Summary for coffee cups

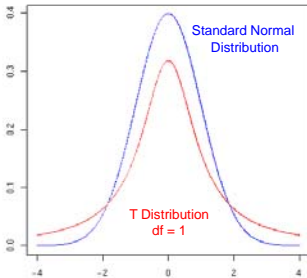



95% Confidence Intervals



Anderson-Darling Normality Test	
A-Squared	0.34
P-Value	0.463
Mean	9.9450
StDev	0.1586
Variance	0.0254
Skewness	-0.209032
Kurtosis	-0.635309
N	20
Minimum	9.5000
1st Quartile	9.7000
Median	9.9000
3rd Quartile	10.0000
Maximum	10.2000
95% Confidence Interval for Mean	
	9.7520 9.9280
95% Confidence Interval for Median	
	9.7235 9.9765
95% Confidence Interval for StDev	
	0.1510 0.2901

New Model: t-Distribution



- Published by William Gosset in 1908
- Shape depends on n
 - Degrees of freedom = $df = n - 1$
- T is flatter than the Normal Distribution
- Larger sample size \rightarrow Closer to Normal
- NEED to use T for small samples

The Sampling Distribution Model:

\bar{y}

What We Settle For	
Model	T-Distribution: Unimodal and Symmetric Thicker Tails than Normal
Mean	Center at μ , the assumed population mean
SD	Larger than the Normal Distribution
SE	Approximate with: s/\sqrt{n}

- Conditions
 - Independence (Random sample, 10% Condition)
 - Nearly Normal Condition

The Conditions

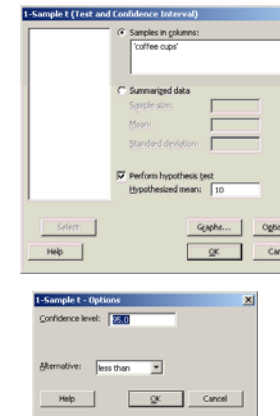
- Independence
 - Randomization, 10% Condition
- Nearly Normal Condition
 - Assumption: Data come from a distribution that is normal.
 - $n < 15$
 - Data should follow the normal closely
 - Check with histogram AND normal probability plot
 - $15 < n < 40$
 - Methods work as long as data are unimodal and reasonably symmetric
 - Check with histogram
 - $n > 40$
 - Methods are relatively safe to use, even without normality

Hypothesis Test

- Is there evidence that the machine is shortchanging customers?
- Step 1: Hypotheses
 - What's our parameter?
 - H_0 :
 - H_A :
- Step 2: The model
 - Check Conditions
 - Make a picture

Hypothesis Test: Mechanics

- Step 3: Mechanics
 - Summarize your information
 - Label your sample information on your model diagram
 - Find the test statistic/p-value
 - Minitab > Stat > Basic
 - Decide "samples in columns" or "summarized data"
 - CHECK "perform hypothesis test"
 - Hypothesized mean = proposed mean in H_0
 - Options
 - Alternative: Select sign from H_A



Just Checking...

One-Sample T: coffee cups
 Test of mu = 10 vs < 10

Variable	N	Mean	StDev	SE Mean	95% Upper Bound	T	P
coffee cups	20	9.8450	0.1986	0.0444	9.9218	-3.49	0.001

DOUBLE CHECK DATA ENTRY (with arrows pointing to the test and variable)

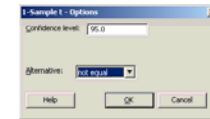
TEST STATISTIC (with arrow pointing to T)

P-VALUE (with arrow pointing to P)

- Step 4: Conclusions?

So...How Much Coffee Is in Each Cup?

- Construct a confidence interval...
- Same Data Entry for hypothesis test EXCEPT
 - Alternative: Select "Not Equal"
 - Note: Minitab 14 does not give an option to check a box to do a hypothesis test



One-Sample T: coffee cups

Variable	N	Mean	StDev	SE Mean	95% CI
coffee cups	20	9.8450	0.1986	0.0444	(9.7520, 9.9380)

- Conclusion?

Vocabulary Preparation for Next Time

- We will perform inference for a mean difference, but the methods we use depend on how the data was collected.
- **Independent Data** (Chapter 24)
 - Sample values from one group are drawn independently from the other group
 - **Ex:** Random assignment of patients in medical trials to drug/placebo
- **Paired Data** (Chapter 25)
 - Observations are collected in pairs, or the observations in one group are naturally related to observations in the other group.
 - Each pair forms a *block*.
 - **Ex:** Random assignment of **twins** to drug/placebo so that in each set of twins, one receives the drug and one receives the placebo.

Which Is It? Independent or Paired?

1. Record ages of a sample of husbands and wives.
2. Record SAT scores of a sample of males and females in a university.
3. Record weights of individuals before and after a diet program.

