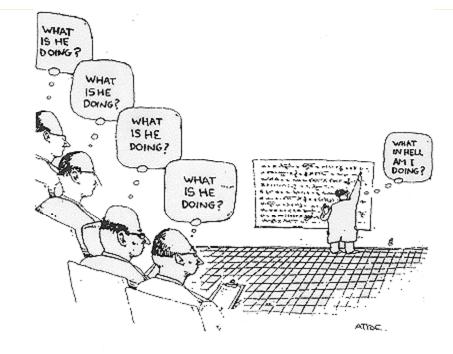
Hypothesis Testing with *t* Tests Arlo Clark-Foos

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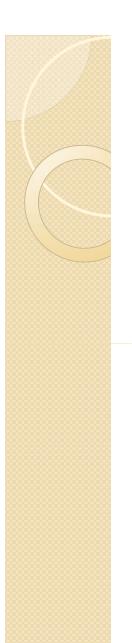
Using Samples to Estimate Population Parameters

- Acknowledge error
- Smaller samples, less spread

$$s = \sqrt{\frac{\Sigma(X - M)^2}{N - 1}}$$

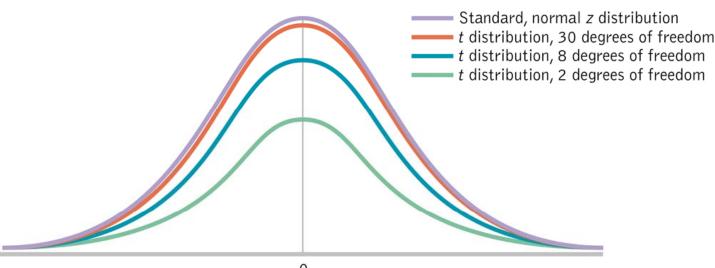






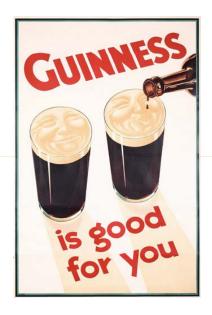
The t Statistic

 Indicates the distance of a sample mean from a population mean in terms of the $s_M = \frac{S}{\sqrt{N}}$ standard error





Hypothesis Tests: Single-Sample *t* Tests

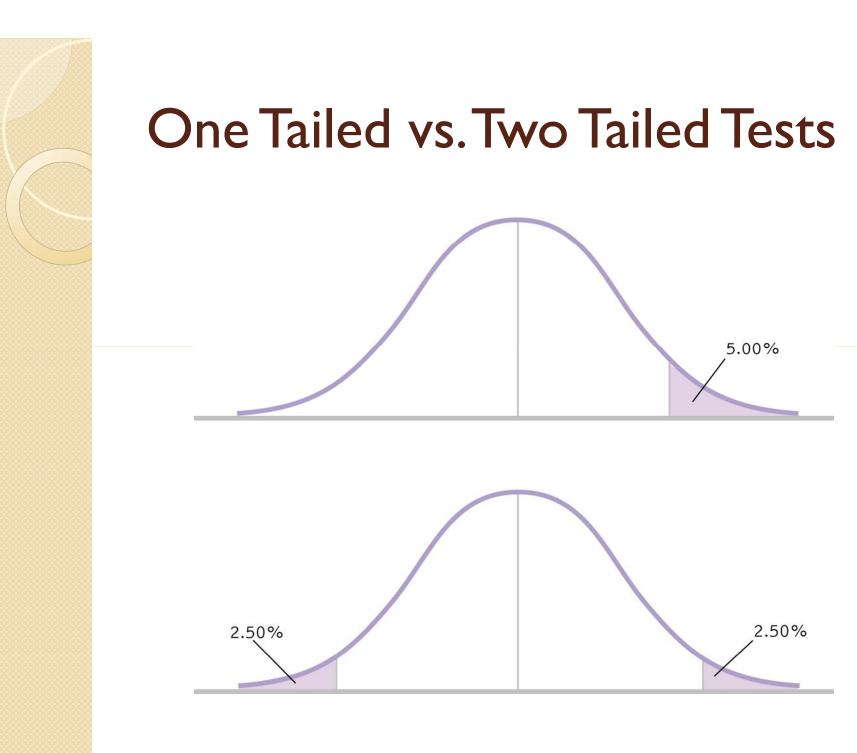




"Guinness is the best beer available, it does not need advertising as its quality will sell it, and those who do not drink it are to be sympathized with rather than advertised to."

Hypothesis Tests: Single-Sample *t* Tests

- Hypothesis test in which we compare data from one sample to a population for which we know the mean but not the standard deviation.
- Degrees of Freedom:
 - The number of scores that are free to vary when estimating a population parameter from a sample
 - df = N I (for a Single-Sample t Test)



Six Steps for Hypothesis Testing

- I. Identify
- 2. State the hypotheses
- 3. Characteristics of the comparison distribution
- 4. Critical values
- 5. Calculate
- 6. Decide

- Participation in therapy sessions
- Contract to attend 10 sessions
- *µ* = 4.6

- Sample:
- 6, 6, 12, 7, 8



"One, please."

I. Identify

- Pop I:All clients who sign contract
- Pop 2:All clients who do not sign contract
- Distribution of means
- Test: Population mean is known but not standard deviation \rightarrow single-sample *t* test
 - Assumptions

- 2. State the null and research hypotheses
 - H₀: Clients who sign the contract will attend the same number of sessions as those who do not sign the contract.

$$\mu_1 = \mu_2$$

 H₁: Clients who sign the contact will attend a different number of sessions than those who do not sign the contract.

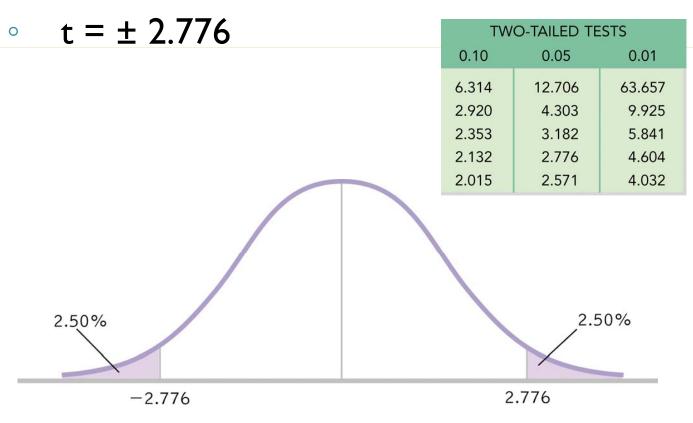
• $\mu_1 \neq \mu_2$

3. Determine characteristics of comparison distribution

$$\mu_{M} = \mu = 4.6,$$

 $s_{M} = 1.114$
 $s = \sqrt{\frac{\Sigma(X - M)^{2}}{N - 1}} = 2.490$

- 4. Determine critical values or cutoffs
 - df = N 1 = 5 1 = 4, p = .05



5. Calculate the test statistic

$$t = \frac{(M - \mu_M)}{s_M} = \frac{(7.8 - 4.6)}{1.114} = 2.873$$

- 6. Make a decision
 - 2.873 > 2.776, we reject the null
 - Clients who sign a contract will attend more sessions than those who do not sign a contract.

Reporting Results in APA Format

- Write the symbol for the test statistic (e.g., z or t)
- 2. Write the degrees of freedom in parentheses
- 3. Write an equal sign and then the value of the test statistic (2 decimal places)
- 4. Write a comma and then whether the p value associated with the test statistic was less than or greater than the cutoff p value of .05

$$t(4) = 2.87, p < .05$$

Hypothesis tests for two samples

 Conditions must be equivalent (controlled) for a fair test



 Beer Tasting: Between-groups vs. Withingroups

Paired-Samples t Test

- Used to compare 2 means for a withingroups design, a situation in which every participant is in both samples (paired/dependent)
- Difference Scores: $X_1 Y_1, X_2 Y_2, \dots$

Paired-Samples t Test

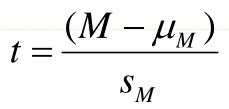
- I. Identify
- 2. State null & research hyp.
- 3. Determine characteristics of comparison distribution

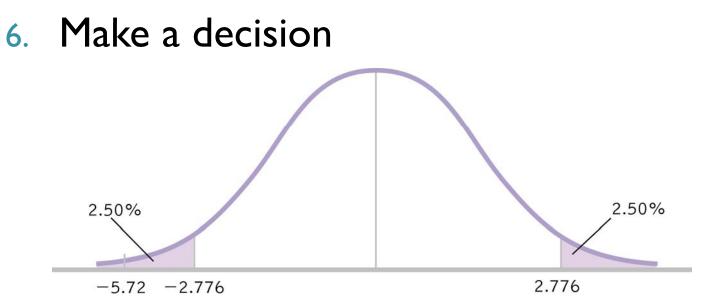
$$H_0: \mu_1 = \mu_2$$

x	Y	DIFFERENCE	DIFFERENCE MEAN DIFFERENCE	SQUARED DEVIATION
122	111	-11	0	0
131	116	-15	-4	16
127	113	-14	-3	9
123	119	-4	7	49
132	12	-11	0	0

Paired-Samples t Test

- 4. Determine cutoffs
- 5. Calculate test statistic





 Used to compare 2 means for a betweengroups design, a situation in which each participant is assigned to only one condition.

TABLE 9-2. HYPOTHESIS TESTS AND THEIR DISTRIBUTIONS

We must consider the appropriate comparison distribution when we choose which hypothesis test we will use.

HYPOTHESIS	NUMBER OF	COMPARISON
TEST	SAMPLES	DISTRIBUTION
z test Single-sample t test Paired-samples t test Independent-samples t test	one one two (same participants) two (different participants)	Distribution of means Distribution of means Distribution of mean difference scores Distribution of differences between means

• What percentage of cartoons do men and woman consider funny?



Women: 84 97 58 90
Men: 88 90 52 97 86

I. Identify

 Population I:Women exposed to humorous cartoons

Population 2: Men exposed to humorous cartoons

- Distribution: Differences between means
 - Not mean differences
- Assumptions are the same
 - We meet one here: DV is interval/scale

0

0

0

0



- 2. State null and research hypotheses
 - $H_0: \mu_1 = \mu_2$
 - Women will categorize the same number of cartoons as funny as will men.
 - $H_1: \mu_1 \neq \mu_2$
 - Women will categorize a different number of cartoons funny as as will men.

3. Determine characteristics of comparison distribution

•
$$H_0: \mu_1 = \mu_2$$

- Measure of spread:
 - a) Calculate variance for each sample
 - b) Pool variances, accounting for sample size
 - c) Convert from squared standard deviation to squared standard error
 - d) Add the two variances
 - e) Take square root to get estimated standard error for distribution of differences between means.

a) Calculate variance for each sample

Х	X - M	$(X - M)^{2}$	
84	1.75	3.063	$s_x^2 = \frac{\Sigma(X-M)^2}{M} = \frac{868.752}{M} = 289.584$
97	14.75	217.563	$s_X^2 = \frac{1}{N_L + 1} = \frac{1}{289.584}$
58	-24.25	588.063	$N - 1 \qquad 4 - 1$
90	7.75	60.063	

Y	Y - M	$(Y - M)^2$
88	5.4	29.16
94	11.4	129.96
52	-30.6	936.36
97	14.4	207.36
86	3.4	11.56

$$s_Y^2 = \frac{\Sigma(Y-M)^2}{N-1} = \frac{1314.4}{5-1} = 328.6$$

Degrees of Freedom

$$df_X = N - I = 4 - I = 3$$

$$df_{\rm Y} = N - 1 = 5 - 1 = 4$$

$$df_{Total} = df_X + df_Y = 3 + 4 = 7$$

Pooled Variance

- b) Pool variances, accounting for sample size
- Weighted average of the two estimates of variance

 one from each sample that are calculated when
 conducting an independent samples t test.

$$s_{Pooled}^{2} = \left(\frac{df_{X}}{df_{Total}}\right)s_{X}^{2} + \left(\frac{df_{Y}}{df_{Total}}\right)s_{Y}^{2}$$

$$s_{Pooled}^2 = \left(\frac{3}{7}\right)289.584 + \left(\frac{4}{7}\right)328.6$$

 $s_{Pooled}^2 = 124.107 + 187.771 = 311.878$

c) Convert from squared standard deviation to squared standard error $s_{Pooled}^2 = 311.878$ $s_{M_X}^2 = \frac{s_{Pooled}^2}{N} = \frac{311.878}{4} = 77.970$ $s_{M_Y}^2 = \frac{s_{Pooled}^2}{N} = \frac{311.878}{5} = 62.376$

d) Add the two variances

$$s_{Difference}^2 = s_{M_X}^2 + s_{M_Y}^2 = 77.970 + 62.376 = 140.346$$

e) Take square root to get estimated standard error for distribution of differences between means.

$$s_{Difference} = \sqrt{s_{Difference}^2} = \sqrt{140.346} = 11.847$$

4. Determine critical values

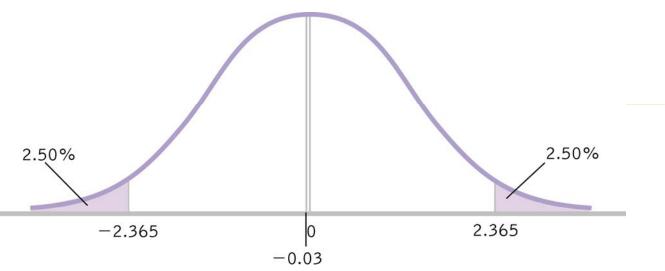
•
$$df_{Total} = 7$$
 $p = .05$ $t = \pm 2.365$

5. Calculate a test statistic

$$t = \frac{\left[\left(M_{X} - M_{Y}\right) - \left(\mu_{X} - \mu_{Y}\right)\right]}{s_{Difference}} = \frac{\left(M_{X} - M_{Y}\right)}{s_{Difference}}$$

$$t = \frac{\left(82.25 - 82.6\right)}{11.847} = -.03$$

6. Make a decision



• Fail to reject null hypothesis

• Men and women find cartoons equally humorous