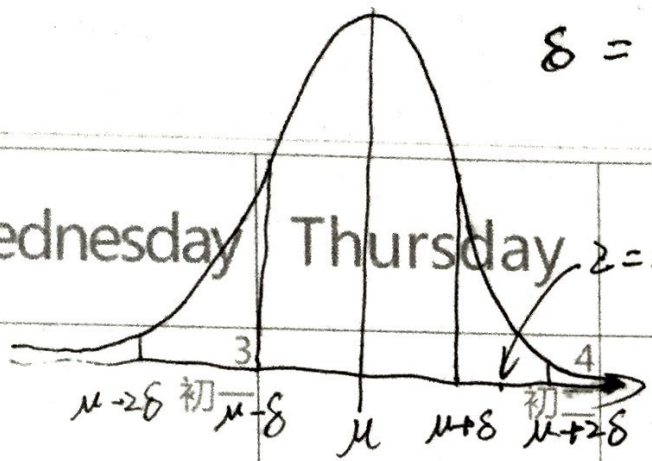
$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n}}$$

2016



z = number of standard deviations away from the mean

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3 初一 | 4 初二 | 5 初三 | 6 初四

Standard deviations away from the mean is definitely a better way to ...

标准化分布图.

获取z值的过程就是将数据归一化的过程.

z值是指任何值距离平均值的标准偏差数.

$$z = \frac{x - \mu}{\sigma}$$

10 初八 | 11 初九 | 12 初十 | 13 十一

When we have any normal distribution, we can standardize it by first subtracting the mean, shifting it to 0. And then dividing ~~the mean~~ by the standard deviation, which makes the standard deviation 1.

14 十五 | 18 十六 | 19 十七 | 20 十八

population mean 总体均值.

SE: standard deviation of distribution of sample means.

sampling distribution.

24 廿二 | 25 廿三 | 26 廿四 | 27 廿五

$$SE = \sigma / \sqrt{n}$$ ← sample size.

← Standard Error.

31 廿九

中心极限定理说明，大量相互独立的随机变量，其均值分布以正态分布为极限

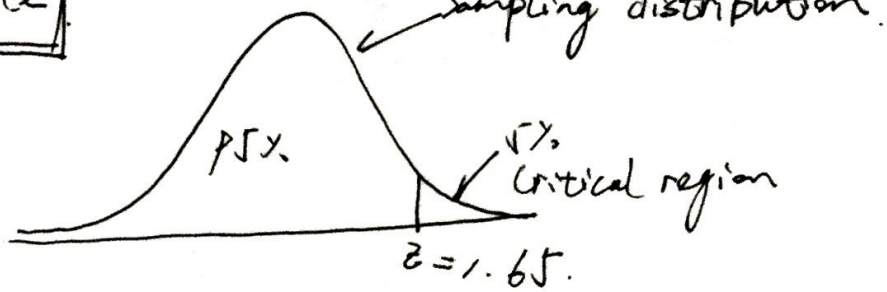
what's our point estimate for the mean of the population after the intervention?

样本量为n的接受干预的样本均值 $\bar{x}_1$

confidence interval = $(\bar{x}_1 - 1.96\frac{s}{\sqrt{n}}, \bar{x}_1 + 1.96\frac{s}{\sqrt{n}})$.

margin of error = $z \cdot \frac{s}{\sqrt{n}}$ (half the width of confidence interval)

假设检验. z-table



α level

$\alpha = 0.05$ (5%)

$\alpha = 0.01$ (1%)

$\alpha = 0.001$ (0.1%)

common α Level. 0.05.

H_0 (null hypothesis): $\mu = \mu_1$

H_a (alternative hypothesis): $\mu < \mu_1$

$\mu > \mu_1$

$\mu \neq \mu_1$

reject null: sample means falls within the critical region.

state of the world	Decision: Reject H_0	Decision: Retain H_0
H_0 true	Type I error	✓
H_0 false	✓	Type II error

t. 检验（t分布是由自由度定义吗）.

z-test works when we know population parameters μ and σ

But much of the time, we don't.

通常只能通过样本得出所有结论.

t-table

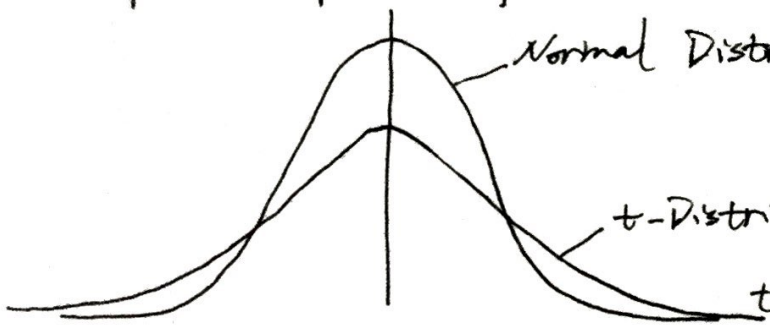
Samples.

1. How different a sample mean is from a population.

2. How different two sample means are from each other.

   - dependent
   - independent.

通过样本标准差估算总体标准差.



DF = n − 1

自由度越大，t分布越接近正态分布.

as n increase:

1. standard error decrease.

2. t-distribution $\Longrightarrow$ normal distribution

3. $s = \sqrt{\frac{\Sigma(x_i - \bar{x})^2}{n-1}} \Longrightarrow \sigma = \sqrt{\frac{\Sigma(x_i - \bar{x})^2}{n}}$.

自由度是指在不影响给定限制条件的情况下.

可以自由变换的信息的数量，可理解自由度视作估算其他信息时可有的独立信息.

$t = \frac{\bar{x} - \mu}{s/\sqrt{n}}$ s: Sample standard diviation.

=

用于判断样本均值与总体均值是否有显著差异.

在对比的值时，效应量效应大小的常见标准之一是 Cohen's d.

Cohen's d is a standardized mean difference that measures the distance between 2 means in standard deviation units.

$$\text{Cohen's } d = \frac{\bar{x} - \mu_0}{s}$$

---

* Dependent t-test for pair samples.

相依样本：same subject takes the test twice

受试者内设计 (within subject design).

- Two conditions $H_0: \mu_1 = \mu_2$.
- Pre-test, Post-test $H_0: \mu_{pre} = \mu_{post}$.
- Growth over time (longitudinal study) $H_0: \mu_{time1} = \mu_{time2}$.

disadvantages:
1. Second measurement can be affected by first measurement
2. Order may influence results

因为是实验性设计，所以可以做出因果阐述

调查研究的一个重要方面是效应量 (effect size).

types of effect size measures

- difference measures
  - mean difference
  - standardized differences (cohen's d)
- correlation measures $r^2 = \frac{t^2}{t^2 + df}$ (t is not t-critical)
  - proportion (%) of variation in one variable that is related to (explained by) another variable.

统计显著性
- rejected the null
- results are not likely due to chance (sampling error)

Independents Samples (Between-subject designs).

$N(\mu_1, \delta_1) - N(\mu_2, \delta_2) = N(\mu_1 - \mu_2, \sqrt{\delta_1^2 + \delta_2^2})$ 2016

standard error $= \frac{s}{\sqrt{n}} = \frac{\sqrt{s_1^2 + s_2^2}}{\sqrt{n}} = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$

$df = n_1 + n_2 - 2$ $\quad t = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{SE}$.

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* ~~报告结果~~.

1. Descriptive Statistics (M, SD).
   in text / graph / tables.
   (描述统计).

2 ~~2nd~~ inferential statistics. (APA styles) 推论统计. 10 初十

a. hypothesis test (for example).
   - α Level.
   - kind of test (one sample t-test).
   - DF.
   - p-value (as exactly as possible).
   - direction of test.

APA style: t (name of the test) (df) = x.xx, p = .xy, direction

$t(xy) = -x.xx$, $p < 0.05$, one-tailed

b. confidence interval
   - confidence level, e.g.: 95%
   - Lower limits & upper limit.
   - ~~C~~ on what.

APA style.
e.g. confidence interval on the mean difference;
95%CI = (4, 6).

3. effect size measures. (d, r^2)

$d = x.xx$ (can be greater than 1) $r^2 = .xx$ (can not be greater than 1)

APA style do not use a leading zero in which we have proportions.

* full one-sample t test.

Formulas:

① $df = n - 1$

② $SEM = \frac{s}{\sqrt{n}}$ (s: Sample standard diviation; n: Sample size)

standard error of mean.

③ $t = \frac{\bar{x} - \mu}{SEM}$ ($\bar{x}$: sample mean; μ: population mean.)

④. CI $\bar{x} \pm$ margin of error ($t_{critical} \times SEM$).

⑤. Cohen's $d = \frac{\bar{x} - \mu}{s}$

⑥ $r^2 = \frac{t^2}{t^2 + df}$

Exercise 1

US families spent an average of μ #1,1 / week on food in 2012. Want to reduce the cost of food, so they implement some cost-saving programs. ← Dependent variable.

treatment.

alternative hypothesis (研究假設): the program did not change the cost of food.

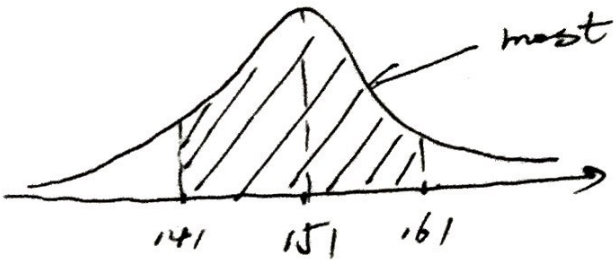
H_0: $\mu_{program} \geq \$1$. one-tailed in "−" direction.

H_A: $\mu_{program} < \$1$

$n = 25$ $df = 24 \Rightarrow t_{critical} = -1.71$ ($\alpha = 0.05$).

$s = \$50$. $SEM = \frac{s}{\sqrt{n}} = 10.00$

this tells us that we expect sample means to differ from the true population mean by $10, on average.



$\bar{x} = 126 \Rightarrow$ mean difference $= \bar{x} - \mu = -25$.

$t = \frac{\bar{x} - \mu}{SEM} = -2.5 < -1.71$ ($t_{critical}$)

$p < 0.05$ (α).

(...p85).

program是否有意义视具体情况而定. 因为与每个家庭的收入有关.

Cohen's $d = \frac{\bar{x} - \mu}{s} = -0.50$. (相差半个标准差).

$r^2 = \frac{t^2}{t^2 + df} = .21$ 表明对于25个人样本来说, 21%的食品价格差异是由成本等计划带来的.

95%CI: $\bar{x} \pm (t_{critical} \times SEM)$

2-tailed, $\alpha = 0.05$ $\Rightarrow t_{critical} = 2.064$ (20.64)

Exercise II

You and your friends want to go out to eat, but you don't want to pay a lot. you decide to either go to Gettysburg or Wilma. you look online and find the average meal prices at 18 restaurants in Gettysburg and 14 restaurants in Wilma.

$H_0: \mu_G = \mu_W$. 需判断两家餐厅在价格上是否

$H_A: \mu_G \neq \mu_W$. 存在显著不同.

△ t 检验的假设是不需要知道总体参数.

$\bar{X}_G = 8.14$. $S_G = 2.6$

$\bar{X}_W = 11.14$ $S_W = 2.18$

$$S_{\bar{X}_G - \bar{X}_W} = \sqrt{\frac{S_G^2}{n_G} + \frac{S_W^2}{n_W}} = 0.8$$

SE / SEM

$$t = \frac{\bar{X}_G - \bar{X}_W}{S_{\bar{X}_G - \bar{X}_W}} \text{ or } -\frac{\bar{X}_W - \bar{X}_G}{S_{\bar{X}_G - \bar{X}_W}} \quad \pm 2.5$$

由于进行的是双尾检验，所以 t 给计量正负都没关系.

$df = n_G + n_W - 2 = 18 + 14 - 2 = 30$.

$t_{critical} = \pm 2.042 > t \Rightarrow$ Reject the null.

t & $df \Rightarrow .01 < \underline{0.05}$.

$$t = -\frac{\bar{X}_A - \bar{X}_B}{\sqrt{\frac{S_A^2}{n_A} + \frac{S_B^2}{n_B}}} \qquad CI: (\bar{X}_A - \bar{X}_B) \pm t \cdot SE$$

↑ $S_{\bar{X}_A - \bar{X}_B}$.

合并方差 $S_p^2 = \frac{SS_1 + SS_2}{df_1 + df_2}$ $SS_x = \Sigma(x_i - \bar{x})^2$.

⇒ 检验标准误差 $\sqrt{\frac{S_p^2}{n_1} + \frac{S_p^2}{n_2}}$

通常，使用合并方差来做假设检验判断，因为它对这3样本量的不同.

2016

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			1 国庆节
5 初五	6 初六	7 初七	8 寒露
12 十一	13 十三	14 十四	15 十五
19	20	21 廿一	22 廿二
26 廿六	27 廿七	28 廿八	29 廿九

$\Sigma(x_i-\bar{x})^2$ $\Sigma(y_i-\bar{y})^2$

Pooled variance $= s_p^2 = \frac{SS_x + SS_y}{df_x + df_y}$

$s_{\bar{x}-\bar{y}} = \sqrt{\frac{s_p^2}{n_x} + \frac{s_p^2}{n_y}}$

$H_0: \mu_x - \mu_y = 10$

$t = \frac{(\bar{x}-\bar{y}) - 10}{s_{\bar{x}-\bar{y}}}$ ← observed difference; expected difference

T-test assumption.

1. X and Y should be random samples from two independent populations.
2. Populations are approximately normal.
3. Sample data can estimate population variances (总体方差).
4. Population variances should be roughly equal.