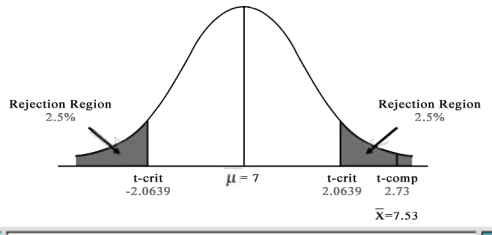
t_{comp} & t_{crit}

- t_{crit} values come from back of text
  - t_{crit} = "REQUIRED" t
- t_{comp} values come from your brain
  - t_{comp} = "ACTUAL" t

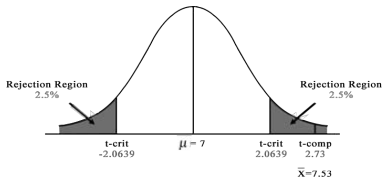
Alternative Decision Rule

- Rejection Region—typically 5%
  - p value ≤ 0.05 = statistical significance



Alternative Decision Rule

- **Reject Null if $|t_{comp}| \geq t_{crit}$**
  - If critical t = 2.0639, then sample & pop means are *required* to be at least 2.0639 standard error units apart in order to reject



What does rejection really mean?

- **Different ways to say it (sort of):**
  - "There is a less than 5 in 100 chance that the sample came from the population."
  - "There is less than a 5% probability that the difference between the sample and population is due to coincidence."
  - "There is a 95% or better probability that the difference between the sample and population is due to the independent variable."

Treating mean differences like z scores

- **z score deviance**
- **Problem: Group distributions contain error and are not normally distributed.**
- **Solution: t distribution**
  - deviance of mean difference

$$t_{\bar{X}} = \frac{\bar{X} - \mu}{s_{\bar{X}}}$$

What is my digit span?

One-Sample t Walkthrough

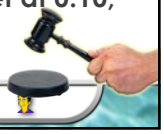
- A researcher is interested in the effect of amphetamine on short-term memory. To test this, she has 25 adult volunteers swallow a small dose of amphetamine, wait 30 minutes, and take a digit-span test. The researcher finds that the mean digit-span for the subjects is 7.53, with a standard deviation of .97. She knows from many previous studies that the average adult digit span is 7. *If we assume that μ=7, what is the probability of selecting a sample of size N = 25, M = 7.53, if only chance is involved?* In other words, how likely is it that the amphetamine had a real (non-chance) effect on digit span?

Minimize chance of Type I error…

- … by making significance level α small.
  - Common values are α = 0.01 and 0.05
    - "How small" depends on seriousness of Type I error
    - Decision is practical not statistical
- **When might we be more or less cautious about making type I errors? In different types of criminal trials?**

P(Type I Error) in trials

- Criminal trials: **"Beyond a reasonable doubt". 12 of 12 jurors must unanimously vote guilty. Significance level α is strict—maybe .001.**
- Civil trials: **"Preponderance of evidence." 9 out of 12 jurors must vote guilty. Significance level α set at 0.10, say.**

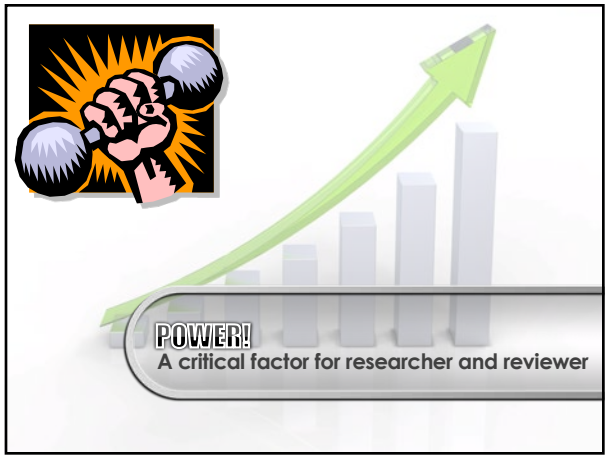


Wanted: Contemplation

- **What are some of the side effects of today's antidepressant drugs?**
- **What are the implications of Type I error when considering post-treatment, mood differences between the control and experimental groups?**
- **What level of alpha would be acceptable to you as a consumer of these products? .05? .01?**

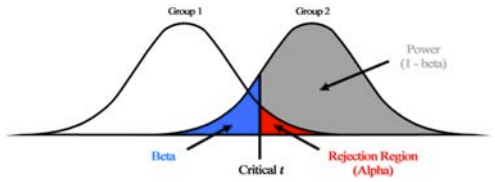
Why is it that when N goes up, t goes down?

- **Sample variance underestimates population variance**
  - problem is worse for small n, so minimum difference between groups must be larger to account for this
- **Minimum sample size 25 or 30, but…**
- **Bigger sample sizes are better!**



Type II Error and Power

- Power: **probability of saying "I found something" when something really is there.**
- **"Power" = 1 – beta**
- **Minimize beta (prob. of Type II), power reflexibely maximized**



Implications

- **1 - GOOD!**
- **0 - BAD!**
- **Me Tarzan. You Jane.**
- **Need make power high as possible, but how?**

(Click image)

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Maximizing power …

- **The farther apart the actual mean is from the mean specified in the null, the higher the power.**
- **The higher the significance level α, the higher the P(Type I error), the higher the power.**
- **The smaller the standard deviation, the higher the power.**
- **The larger the sample, the higher the power…**

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If sample size is too…

- **…small**, then power can be too low to identify even large meaningful differences.
- **…large**, the power can be extremely high for identifying even meaningless differences.
- **Moral of the story:**
  - Always be cautious of sample size when interpreting studies.
  - Use confidence intervals to back up claims.

Wanted: Contemplation

- **Assume that the 327 students who have taken statistics at a large university constitute a population. Each student has been given a math achievement test with the following results: μ = 53.7. One sample of 25 students has been drawn from the population, and the average test score has been found to be 55.1, with *s* = 8.5. Test the null hypothesis that sample and population means are equal. CHOOSE YOUR OWN ALPHA AND JUSTIFY.**

$$s_{\bar{X}} = \frac{s}{\sqrt{N}} \qquad t_{\bar{X}} = \frac{\bar{X} - \mu}{s_{\bar{X}}}$$