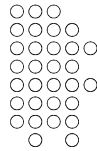


Sampling Distributions and Hypothesis Testing

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 Ψ 320
Ainsworth



Major Points

- Sampling distribution – What are they?
- Hypothesis testing
 - The null hypothesis
 - Test statistics and their distributions
 - The normal distribution and testing
- Some other Important concepts

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Hypothetical Study on Intelligence

- Can we create a pill that when taken regularly (like a vitamin) increases intelligence?
- A group of 25 participants are given 30mg of IQPLUS everyday for ten days
- At the end of 10 days the 25 participants are given the Stanford-Binet intelligence test.

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IQPLUS: Results



- The mean IQ score of the 25 participants is 106 (the average score for IQ in the population is 100)
- Is this increase large enough to conclude that IQPLUS was effective in increasing the participants IQ?

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What is the REAL Question?



- Is the difference between 106 and 100 large enough to lead us to conclude that it is a real difference?
 - Would we expect a similar kind of difference with a repeat of this experiment?
 - Or...
 - Is the difference due to something called "sampling error"?

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Sampling Error



- AKA sampling variation
- The normal variability that we would expect to find from one sample to another, or one study to another
- Random variability among observations or statistics that is just due to chance

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How Could we Assess Sampling Error?



- Take many groups of 25 participants who did *not* get IQPLUS.
- Record the average IQ score for each group.
- Plot the distribution and record its mean and standard deviation.
- This distribution is called a “Sampling Distribution.”

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Sampling Distribution

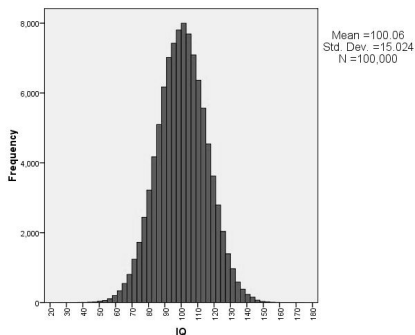


- The distribution of a statistic over repeated sampling from a specified population.
- Possible result for this example.
 - See next slide.
 - Shows the kinds of means we expect to find when people don't take IQPLUS.

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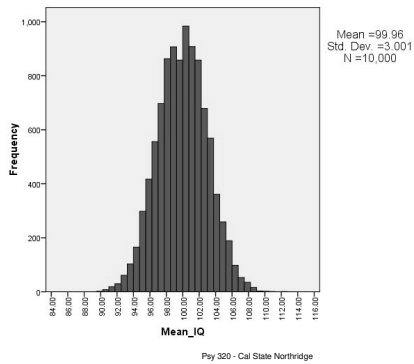
Population Distribution



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Population Distribution



What Do We Conclude?

- When people don't get IQPLUS the majority of sample means fall between 96 and 104
- Our IQPLUS group had an average IQ score of 106
 - Our subjects' responses were not like normal.
- Conclude that IQPLUS increased intelligence

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Sampling Distribution

- Central Tendency
 - "typical value"
 - Usually estimates the population parameter
 - The mean is the mean of the means
- Dispersion - Standard Error
 - "variability"
 - The SD of a sampling distribution is called the Standard Error (SE)
- Shape - depends upon the statistic and the assumptions

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Hypothesis Testing



- A formal way of doing what we just did
- Start with hypothesis that subjects are normal.
 - The null hypothesis
- Find what normal subjects do.
- Compare our subjects to that standard.

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Steps in Hypothesis Testing



- Define the null hypothesis.
- Decide what you would expect to find if the null hypothesis were true.
- Look at what you actually found.
- Reject the null if what you found is not what you expected.

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Hypothesis Testing Steps



1. State Null Hypothesis (H_0)
2. Alternative Hypothesis (H_1)
3. Decide on α (usually .05)
4. Decide on type of test
5. Find critical value & state decision rule
6. Calculate test
7. Apply decision rule

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H_0 and H_1



- Always stated in terms of population parameters, never sample statistics.
- Together, define the entire range of possibilities.
- $H_0: \mu = 0$
- $H_1: \mu \neq 0$

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The Null Hypothesis



- The hypothesis that our subjects came from a population of normal responders.
- The hypothesis that taking IQPLUS has no affect on intelligence.
- The hypothesis we usually want to reject.

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The Null Hypothesis



- Specifies a **single value** (has the equals sign in it somewhere)
- Says:
 - "Nothing happened."
 - "There's no difference."
 - "Chance is a good explanation for your results."
 - "Your sample statistic doesn't differ from your hypothesized population parameter." ¹⁸

The Research Hypothesis



- Also known as the “alternative hypothesis”
- Always specifies a **range of values** (has an inequality in it somewhere)
- Says,
 - “Something happened.”
 - “There **is** a difference.”
 - “Chance is not a good explanation for your results.”
 - “Your sample statistic differs ‘significantly’ from your hypothesized population parameter.”

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Important Concepts



- Concepts critical to hypothesis testing
 - It's all probability
 - Decision
 - Type I error
 - Type II error
 - Critical values
 - One- and two-tailed tests

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Probability Statement



- The Unsettling Part to it all
- **YOU** decide on the odds for casting your decision in favor of H_0 or H_1 .
- Even after you decide, you're still never certain if you made the right decision.
- All your choices are based upon probability distributions (sampling distributions).
- ***Nothing is ever proved!!***

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Decisions



- When we test a hypothesis we draw a conclusion; either correct or incorrect.
 - Type I error
 - Reject the null hypothesis when it is actually correct.
 - Type II error
 - Retain the null hypothesis when it is actually false.

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Type I Errors



- Assume IQPLUS really has no effect on intelligence
- Assume we conclude that IQPLUS does work.
- This is a Type I error
 - Probability set at alpha (α)
 - α usually at .05
 - Therefore, probability of Type I error = .05

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Type II Errors



- Assume IQPLUS makes a difference
- Assume that we conclude it doesn't
- This is also an error (Type II)
 - Probability denoted beta (β)
 - We can't set beta easily.
 - We'll talk about this issue later.
- Power = $(1 - \beta)$ = probability of correctly rejecting false null hypothesis.

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Confusion Matrix

		Reality	
		H ₀	H ₁
Your Decision	"H ₀ "	1 - α	β
	"H ₁ "	α	1 - β
		1.00	1.00

		Reality	
		H ₀	H ₁
Your Decision	"H ₀ "	.95	.16
	"H ₁ "	.05	.84
		1.00	1.00

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Critical Values

- These represent the point at which we decide to reject null hypothesis.
- e.g. We might decide to reject null when $(p|_{\text{null}}) \leq .05$.
 - Our test statistic has some value with $p = .05$
 - We reject when we exceed that value.
 - That value is the critical value.

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One- and Two-Tailed Tests

- Two-tailed test rejects null when obtained value too extreme in *either* direction
 - Decide on this before collecting data.
- One-tailed test rejects null if obtained value is too low (or too high)
 - We only set aside one direction for rejection.

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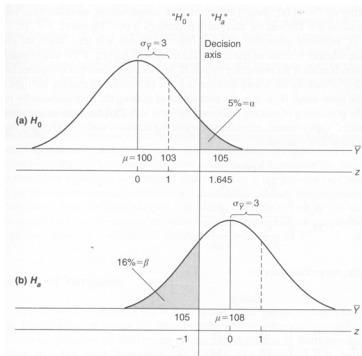
One- & Two-Tailed Example

- One-tailed test
 - Reject null if IQPLUS group shows an increase in IQ
 - Probably wouldn't expect a reduction and therefore no point guarding against it.
- Two-tailed test
 - Reject null if IQPLUS group has a mean that is substantially higher or lower.

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Hypothesis Testing and Z



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1-tailed example ($\alpha = .05$)

- All 5% in one tail

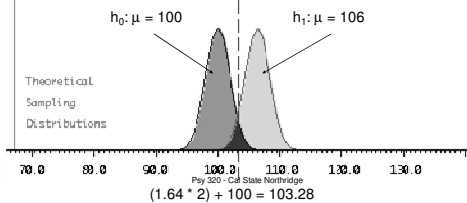
$$\frac{103.28 - 106}{2} = -1.36$$

Table E.10 - smaller area of $-1.36 = .087$

$\beta = .087$

Table E.10 - smaller area of $= .913$

Power $= 1 - \beta = .91$



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2-tailed example ($\alpha = .05$)

- 5% split into 2 tails
(2.5% in each tail)

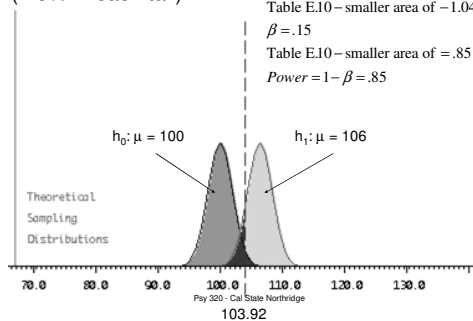
$$\frac{103.92 - 106}{2} = -1.04$$

Table E.10 – smaller area of $-1.04 = .149$

$$\beta = .15$$

Table E.10 – smaller area of $= .851$

$$\text{Power} = 1 - \beta = .85$$



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