PSYCHOLOGY 300B
Statistical Methods in Psychology: II

• Professor
  Dr. Michael Masson
  Office: Cornett A183 (enter through A177)
  Office hours: Tuesday 11 AM–12:30 PM, or by appointment
  Phone: 250-721-7536
  e-mail: mmteach@uvic.ca
  web site: web.uvic.ca/psyc/masson
  • lecture slides and audio recordings of lectures
  • web link to text-related resources (e.g., stat tables)

• Teaching Assistants
  Max Pittman (mpittman@uvic.ca)
  Myles Maillet [tutorials] (maillet1@uvic.ca)
• **Lectures**
  Monday & Thursday, 11:30 a.m. – 12:50 p.m.
  Cornett B108

• **Tutorials**
  • expect 7 or 8 tutorials, announced in class or on web site
  • Tuesday 9:30 AM – 10:20 AM – Clearihue A212
  • Friday 11:30 AM – 12:20 PM – Cornett A128
• **Text Book** (optional)


Aplia (supplemental exercises)

Suggested on-line text book

http://onlinestatbook.com

• **Objectives**
  
  • develop understanding of some basic statistical analyses applied in psychological research
  • understand logic and theory behind each analysis, its computational procedures, circumstances of it use, and interpretation of its results
  • examinations will test this understanding
  • classroom lectures are the *essential* component
• **Study Groups**
  
  • formation of study groups is recommended
  • e-mail professor if interested (mmteach@uvic.ca)
  • deadline: January 14

• **Evaluation**

  Examination 1: Thursday, January 31 (20%)
  Examination 2: Thursday, March 7 (25%)
  Final examination: April 8 - 27 (35%)
  Research proposal: Thursday, February 28 (5%)
  Research report: Monday, March 25 (15%)
• Schedule of Topics
  
  Review of essential concepts
  Testing hypotheses about two population means
  Power to detect an effect

{Examination 1}

  Analysis of variance: Hypotheses about more than two population means
  Analysis of variance: Two independent variables and the concept of interaction

{Examination 2}

  Analysis of variance: Repeated measurement of subjects
  Analysis of frequencies (nominal measurement scale)
  Introduction to Bayesian analysis
Review of Essential Concepts

• Random sampling and random assignment

• Inferring cause and effect
  • can a correlation imply a causal influence?

• z score transformations
  • what result is obtained when z score transformation is applied to a uniform distribution?

\[ z = \frac{X - M}{s} \]

• a bimodal distribution?
Review of Essential Concepts

• Standard normal distribution \[ z = \frac{X - M}{S} \]

• Problem: what is the probability of randomly drawing a z score greater than or equal to 1.0?
  • a z score between –1 and –2, inclusive, or between 0 and 1, inclusive?
  • a z score of 0.75 or greater?
Review of Essential Concepts

<table>
<thead>
<tr>
<th>$z$</th>
<th>Mean to $z$</th>
<th>Larger Portion</th>
<th>Smaller Portion</th>
</tr>
</thead>
<tbody>
<tr>
<td>.73</td>
<td>0.2673</td>
<td>0.7673</td>
<td>0.2327</td>
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<tr>
<td>.74</td>
<td>0.2704</td>
<td>0.7704</td>
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<tr>
<td>.76</td>
<td>0.2764</td>
<td>0.7764</td>
<td>0.2236</td>
</tr>
<tr>
<td>.77</td>
<td>0.2794</td>
<td>0.7794</td>
<td>0.2206</td>
</tr>
</tbody>
</table>
• Distribution of sample means

• consider a simple population of 8 scores
  1  2  3  4  5  6  7  8

• how many different samples of $N = 4$ can be drawn (without replacement) from this population?

$$8 \binom{4}{8} = \frac{8!}{(8 - 4)!4!} = \frac{8(7)(6)(5)}{4!} = 70$$

Draw an arbitrary sample of $N = 4$ and compute $M$
Review of Essential Concepts

• Distribution of sample means
  • consider a population of 100 raw scores
    • how many different samples of $N = 4$ can be drawn (without replacement) from this population?

\[ 100C_4 = 3,921,225 \]
Review of Essential Concepts

• Distribution of sample means

\[ \mu_M = \mu \]
\[ \sigma_M = \frac{\sigma}{\sqrt{N}} \]
Review of Essential Concepts

• Logic of hypothesis testing for a population mean
  • construct a model of all possible outcomes

Population of raw scores

Distribution of sample means

100
\( \sigma = 15 \)

All samples of N = 40

100
\( \sigma_M = 2.37 \)

Reminder

\[ \sigma_M = \frac{15}{\sqrt{40}} \]

NOTE: If there are 500 scores in this population, then there are \( 2.24 \times 10^{59} \) possible samples of size 40 (a trillion is only \( 10^{12} \))
Review of Essential Concepts

• Logic of hypothesis testing for a population mean
  • construct a model of all possible outcomes

Population of raw scores

Distribution of sample means

100
\( \sigma = 15 \)

All samples of \( N = 40 \)

100
\( \sigma_M = 2.37 \)

• If an unlikely sample mean is obtained
  • just a fluke?
  • reason to reject \( H_0 \)
Review of Essential Concepts

• Hypothesis testing: single population mean
  • Headstart program may improve intelligence test scores of young children
    \( \mu = 100 \quad \sigma = 15 \)
  • directional or nondirectional hypothesis?
  • \( H_0 : \mu = 100 \quad H_1 : \mu > 100 \)
  • use .05 significance level: critical \( z = 1.65 \)

\[ N = 40 \quad M = 105 \]

\[ Z = \frac{M - \mu}{\sigma_M} = \frac{105 - 100}{2.37} = 2.11 \]

\[ p = .0174 \quad p < .05 \]
Review of Essential Concepts

• Hypothesis testing: single population mean
  • use of the \( t \) distribution when \( \sigma \) is not known
    • \( H_0: \mu = 100 \quad H_1: \mu > 100 \)
    • \( N = 40 \quad M = 105 \quad s = 18 \) (estimate of \( \sigma \))

\[
s_M = \frac{18}{\sqrt{40}} = 2.85 \quad \text{(estimate of } \sigma_M)\]

\[
t = \frac{M - \mu}{s_M} = \frac{105 - 100}{2.85} = 1.75
\]

\[
t \quad \text{df} = 39
\]

\[
0 \quad 1.685 \quad .05
\]
Review of Essential Concepts

• Evolution of the $t$ distribution
Review of Essential Concepts

- $H_0: \mu = 100 \quad H_1: \mu > 100$
- $N = 40 \quad M = 105 \quad s = 18$ (estimate of $\sigma$)

**Directional (one-tailed) test**

$$t = \frac{105 - 100}{2.85} = 1.75$$

$p = .044$

**Nondirectional (two-tailed) test**

$$-1.75 \quad 1.75$$

$p = .088$
Review of Essential Concepts

• Related-samples $t$ test

• drug expected to reduce symptoms of anxiety

• $H_0: \mu_1 = \mu_2 \quad H_1: \mu_1 > \mu_2 \quad (1 = \text{placebo}, \ 2 = \text{drug})$

<table>
<thead>
<tr>
<th>Subj</th>
<th>Place.</th>
<th>Drug</th>
<th>Diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>5</td>
<td>-1</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>3</td>
<td>2</td>
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<td>...</td>
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<tr>
<td>20</td>
<td>7</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

$M_D = 3.2 \quad s_D = 5.7$

$$\begin{align*}
S_{MD} &= \frac{s_D}{\sqrt{N}} = \frac{5.7}{\sqrt{20}} = 1.27 \\
t &= \frac{M_D - 0}{s_{MD}} = \frac{3.2 - 0}{1.27} = 2.52
\end{align*}$$

Critical $t$ ratio for a one-tailed test:

$t_{\text{crit}}(19) = 1.729$

Reject $H_0 \quad t(19) = 2.52, \ p < .05$