Homework Exercises for PSYC 3330: Statistics for the Behavioral Sciences

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1 The Basics: Measurement and Displaying Data

1. A researcher is interested in the texting habits of high school students in the United States. The researcher selects a group of 100 students, measures the number of text messages that each individual sends each day, and calculates the average number for the group.

   (a) Identify the population for this study.

   (b) Identify the sample for this study.

2. A tax form asks people to identify their annual income, number of dependents, and social security number. For each of these three variables, identify the scale of measurement that is likely used, and identify whether the variable is continuous or discrete.

3. Weinstein, McDermott, and Roediger (2010) conducted an experiment to evaluate the effectiveness of different study strategies. One part of the study asked students to prepare for a test by reading a passage. In one condition, students generated and answered questions after reading the passage. In a second condition, students simply read the passage a second time. All students were then given a test on the passage material and the researchers recorded the number of correct answers

   - Identify the dependent variable for this study.
   - Is the dependent variable discrete or continuous?
   - What scale of measurement (nominal, ordinal, interval, or ratio) is used to measure the dependent variable?

4. We have talked about four scales of measurement: nominal, ordinal, interval, and ratio.

   - What additional information is obtained from measurements on an ordinal scale compared to measurements on a nominal scale?
   - What additional information is obtained from measurements on an interval scale compared to measurements on a ordinal scale?
   - What additional information is obtained from measurements on an ratio scale compared to measurements on a interval scale?

5. Place the following scores in a frequency distribution table and construct a histogram. Based on this information, what is the shape of the distribution?

13	14	12	15	15	14	15	11	13	14
11	13	15	12	14	14	10	14	13	15

6. For the following set of scores, construct a frequency distribution table and a histogram. What is the shape of the distribution?

8	6	7	5	4	10	8	9	5	7	2	9
9	10	7	8	8	7	4	6	3	8	9	6

7. For the following scores, the smallest value is $X = 13$ and the largest value is $X = 52$. Place the scores in a grouped frequency distribution table,

- using an interval width of 5 points.
- using an interval width of 10 points.

44	19	23	17	25	47	32	26
25	30	18	24	49	51	24	13
43	27	34	16	52	18	36	25

8. For each of the following samples, determine the interval width that is most appropriate for a grouped frequency distribution and identify the approximate number of intervals needed to cover the range of scores.
   - Sample scores range from $X = 8$ to $X = 41$
   - Sample scores range from $X = 16$ to $X = 33$
   - Sample scores range from $X = 26$ to $X = 98$
9. Describe the difference in appearance between a bar graph and a histogram and describe the circumstances in which each type of graph is used.
10. What information is available about the scores in a regular frequency distribution table that you cannot obtain for the scores in a grouped table?

2 Measures of Central Tendency and Variation

1. Find the mean, median, and mode for the following scores:

$$5 \quad 4 \quad 5 \quad 2 \quad 7 \quad 1 \quad 3 \quad 5$$

2. Find the mean, median, and mode for the scores in the following frequency distribution table:

X	f
6	1
5	2
4	2
3	2
2	2
1	5

3. A set of $N = 15$ scores has $\sum X = 120$. What is the mean?
4. A set of $n = 8$ scores has a mean of $M = 12$. What is the value of $\sum X$ for this sample?
5. A set of scores has a mean of $M = 8$ and $\sum X = 40$. How many scores are in the set?
6. A set of $n = 7$ scores has a mean of $M = 16$. One score in the set is changed from $X = 6$ to $X = 20$. What is the value for the new mean after this adjustment?
7. Calculate SS, variance, and standard deviation for the following set of scores: 2, 13, 4, 10, 6
8. For the following set of score:

$$2 \quad 9 \quad 6 \quad 8 \quad 9 \quad 8$$

   (a) calculate the range and standard deviation
   (b) Add 2 points to each score and compute the range and standard deviation again. Describe how adding a constant to each score influences measures of variability.

9. For a distribution with $\mu = 60$ and $\sigma = 12$
   (a) find the z-score for each of the following X values

$$\begin{array}{ccc} X = 75 & X = 48 & X = 84 \\ X = 54 & X = 78 & X = 51 \end{array}$$

   (b) Find the raw score (X-value) for each of the following z-scores

$$\begin{array}{ccc} z = 1.00 & z = 0.25 & z = 1.50 \\ z = -0.50 & z = -1.25 & z = -2.50 \end{array}$$

10. A distribution with a mean of $\mu = 76$ and a standard deviation of $\sigma = 12$ is transformed into a standardized distribution with $\mu = 100$ and $\sigma = 20$. Find the new, standardized score for each of the following values from the original distribution:

    (a) $X = 61$

    (b) $X = 70$

    (c) $X = 85$

    (d) $X = 94$

3 Correlation

1. For the following scores:

X	2	5	4	7	2	4
Y	7	4	7	5	6	7

   (a) Sketch a scatter plot and estimate the Pearson correlation.
   (b) Compute the Pearson correlation.

2. For the following scores:

X	0	2	1	1
Y	4	9	6	9

   (a) Sketch a scatter plot and estimate the Pearson correlation.
   (b) Compute the Pearson correlation.

3. For the following scores:

X	4	1	1	4
Y	0	5	0	5

   (a) Sketch a scatter plot and estimate the Pearson correlation.
   (b) Compute the Pearson correlation.

4. For the following scores:

X	3	5	6	6	5
Y	6	5	0	2	2

   (a) Sketch a scatter plot and estimate the Pearson correlation.
   (b) Compute the Pearson correlation.

5. For the following scores:

X	4	6	3	9	6	2
Y	5	5	2	4	5	3

   (a) Compute the Pearson correlation

(b) Add two points to each X value and re-compute the correlation for the modified scores. How does adding a constant to every score affect the value of the correlation?

(c) Multiply each of the original X values by 2 and re-compute the correlation for the modified scores. How does multiplying each score by a constant affect the value of the correlation?

4 Probability and the Normal Distribution

1. Find each of the following probabilities for a normal distribution:
   (a) $P(z > 1.25)$
   (b) $P(z > -0.60)$
   (c) $P(z < 0.70)$
   (d) $P(z < -1.30)$

2. What proportion of the normal distribution is located between each of the following z-score boundaries?
   (a) $z = -0.25$ and $z = +0.25$
   (b) $z = -1.20$ and $z = +1.20$
   (c) $z = +0.20$ and $z = +1.50$
   (d) $z = -0.50$ and $z = +1.00$

3. Find the z-score location of the vertical line that separates a normal distribution as described in each of the following:
   (a) 5% in the tail on the left
   (b) 30% in the tail on the right
   (c) 65% in the body on the left
   (d) 80% in the body on the right

4. A normal distribution has a mean of $\mu = 70$ and a standard deviation of $\sigma = 8$. For each of the following scores, indicate whether the tail is to the right or left of the score, and find the proportion of the distribution located in the tail.
   (a) $X = 72$
   (b) $X = 76$
   (c) $X = 66$
   (d) $X = 60$

5. For a normal distribution with a mean of $\mu = 60$ and a standard deviation of $\sigma = 10$, find the proportion of the population corresponding to each of the following:
   (a) Scores greater than 65
   (b) Scores less than 68
   (c) Scores between 50 and 70

6. The distribution of scores on the SAT is approximately normal with a mean of $\mu = 500$ and a standard deviation of $\sigma = 100$. For the population of students who have taken the SAT,
   (a) What proportion have SAT scores less than 400?
   (b) What proportion have SAT scores greater than 650?

(c) What is the highest minimum SAT score needed to be in the highest 20% of the population?

(d) If a state college only accepts students from the top 40% of the SAT distribution, what is the minimum SAT score needed to be accepted?

5 Introduction to Hypothesis Testing

1. Define Type I error and Type II error, and explain the consequences of each.

2. If the alpha level is changed from $\alpha = 0.05$ to $\alpha = 0.01$,

   (a) What happens to the boundaries for the critical region?

   (b) What happens to the probability of a Type I error?

3. The value of the z-score in a hypothesis test is influenced by a variety of factors. Assuming that all other variables are held constant, explain how the value of z is influenced by each of the following. In other words, what happens to the z-score? Does it increase/decrease/stay the same? Why?

   (a) Increasing the difference between the sample mean and the original population mean.

   (b) Increasing the population standard deviation.

4. Although there is popular belief that herbal supplements such as Ginkgo biloba and Ginseng may improve memory and learning in healthy adults, such results are usually not supported by well-controlled studies. In a typical study, a researcher asks a participant to take an herbal supplement every day for 90 days. At the end of the 90 days, the participant takes a standardized memory test. For the general population, it is known that the scores for the test form a normal distribution with $\mu = 50$ and $\sigma = 12$. The research participant scores a 64 on the memory test.

   (a) Assuming a two-tailed test, state the null hypothesis for the study.

   (b) Conduct a two-tailed hypothesis test with $\alpha = 0.05$ to evaluate the effect of the supplements.

5. Using the same data and the same method of analysis, the following hypotheses are tested regarding whether mean height is 72 inches. Researcher A uses $\alpha = 0.05$, whereas Researcher B uses $\alpha = 0.01$.

$$H_0 : \mu = 72$$
$$H_A : \mu \neq 72$$

   (a) If Researcher A rejects H_0, what is the conclusion of Researcher B? Why?

   (b) If Researcher B rejects H_0, what is the conclusion of Researcher A? Why?

   (c) If Researcher A fails to reject H_0, what is the conclusion of Researcher B? Why?

   (d) If Researcher B fails to reject H_0, what is the conclusion of Researcher A? Why?

6 Testing means of samples of *known* populations (z-tests)

1. A random sample is selected from a normal population with a mean of $\mu = 30$ and a standard deviation of $\sigma = 8$. After a treatment is administered to the individuals in the sample, the sample mean is found to be $M = 33$.
   (a) If the sample consists of $n = 16$ scores, is the sample mean sufficient to conclude that the treatment has a significant effect? Use a two-tailed test with $\alpha = 0.05$.
   (b) If the sample consists of $n = 64$ scores, is the sample mean sufficient to conclude that the treatment has a significant effect? Use a two-tailed test with $\alpha = 0.05$.
   (c) Comparing your answers for parts (a) and (b), explain how the size of the sample affects the outcome of a hypothesis test.

2. A random sample of $n = 25$ scores is selected from a normal population with a mean of $\mu = 40$. After a treatment is administered to the individuals in the sample, the sample mean is found to be $M = 44$.
   (a) If the population standard deviation is $\sigma = 5$, is the sample mean sufficient to conclude that the treatment has a significant effect? Use a two-tailed test with $\alpha = 0.05$.
   (b) If the population standard deviation is $\sigma = 15$, is the sample mean sufficient to conclude that the treatment has a significant effect? Use a two-tailed test with $\alpha = 0.05$.
   (c) Comparing your answers for parts (a) and (b), explain how the magnitude of the standard deviation affects the outcome of a hypothesis test.

3. A high school teacher has designed a new course intended to help students prepare for the mathematics section of the SAT. A sample of $n = 20$ students is recruited to take the course and, at the end of the year, each student takes the SAT. The average score for this sample is $M = 562$. For the general population, scores on the SAT are standardized to form a normal distribution with $\mu = 500$ and $\sigma = 100$.
   (a) Can the teacher conclude that students who take the course score significantly higher than the general population? Use a one-tailed test with $\alpha = 0.01$.
   (b) Compute Cohen's d to estimate the size of the effect.

4. Briefly explain how increasing sample size affects each of the following. Assume that all other factors are held constant.
   (a) The size of the z-score in a hypothesis test
   (b) The size of Cohen's d
   (c) The power of a hypothesis test

5. Explain how the power of a hypothesis test is affected by each of the following. Assume that all other factors are held constant.
   (a) Increasing the alpha level from 0.01 to 0.05
   (b) Changing from a one-tailed to a two-tailed test

7 Testing means of samples of *unknown* populations (t-tests)

1. A random sample of $n = 25$ individuals is selected from a population with $\mu = 20$, and a treatment is administered to each individual in the sample. After treatment, the sample mean is found to be $M = 22.2$ with $SS = 384$. Based on the sample data, does the treatment have a significant effect? Use a two-tailed test with $\alpha = 0.05$.

2. To evaluate the effect of a treatment, a sample is obtained from a population with a mean of $\mu = 30$ and the treatment is administered to the individuals in the sample. After treatment, the sample mean is found to be $M = 31.3$ with a standard deviation of $s = 3$.

   (a) If the sample consists of $n = 16$ individuals, are the data sufficient to conclude that the treatment has a significant effect using a two-taile test with $\alpha = 0.05$?

   (b) If the sample consists of $n = 36$ individuals, are the data sufficient to conclude that the treatment has a significant effect using a two-taile test with $\alpha = 0.05$?

   (c) Comparing your answers for parts (a) and (b), how does the size of the sample influence the outcome of a hypothesis test?

3. Standardized measures seem to indicate that the average level of anxiety has increased gradually over the past 50 years (Twenge, 2000). In the 1950s, the average score on the Child Manifest Anxiety Scale was $\mu = 15.1$. A sample of $n = 16$ of today's children produces a mean score of $M = 23.3$ with $SS = 240$. Based on this sample, has there been a significant change in the average level of anxiety since the 1950s? Use a two-tailed test with $\alpha = 0.01$.

4. A sample of $n = 9$ individuals participates in a repeated measures study that produces a sample mean difference of $M_D = 4.25$ with $SS = 128$ for the difference scores. Is this mean difference large enough to be considered a *significant increase*? Use a two-tailed test with $\alpha = 0.05$.

5. The following data are from a repeated measures study examining the effect of a treatment by measuring a group of $n = 6$ participants before and after they receive the treatment.

Before	After
7	8
2	9
4	6
5	7
5	6
3	8

   (a) Calculate the difference scores and the mean difference M_D

   (b) Compute SS, sample variance, and estimated standard error.

   (c) Is there a significant treatment effect? Use a two-tailed test with $\alpha = 0.05$.

8 t-tests with Independent Samples

1. Two separate samples, each with $n = 15$ individuals, receive different treatments. After treatment, the first sample has $SS = 1740$ and the second sample has $SS = 1620$.

   (a) Find the pooled variance for the two samples.

   (b) Compute the estimated standard error for the sample mean difference.

   (c) If the sample mean difference is 8 points, is this enough to reject the null hypothesis and conclude that there is a significant difference for a two-tailed test at the 0.05 level?

2. It appears that there is some truth to the old adage "That which doesn't kill us makes us stronger". Seery, Holman, and Silver (2010) found that individuals with some history of adversity report better mental health and higher well-being compared to people with little or no history of adversity. In an attempt to examine this phenomenon, a researcher surveys a group of college students to determine the negative life events that they experienced in the past 5 years and their current feeling of well-being. For $n = 18$ participants with 2 or fewer negative experiences, the average well-being score is $M = 42$ with $SS = 398$, and for $n = 16$ participants with 5 to 10 negative experiences the average score is $M = 48.6$ with $SS = 370$.

   (a) Is there a significant difference between the two populations represented by these two samples? Use a two-tailed test with $\alpha = 0.01$.

   (b) Compute Cohen's d to measure the size of the effect.

3. In 1974, Loftus and Palmer conducted a classic study demonstrating how the language used to ask a question can influence eyewitness memory. In the study, college students watched a film of an automobile accident and then they were asked questions about what they saw. One group was asked "About how fast were the cars going when they smashed into each other?" Another group was asked the same question except the verb was changed to "hit" instead of "smashed into". The "smashed into" group reported significantly higher estimates of speed than the "hit" group. Suppose a researcher repeats the study with a sample of today's college students and obtains the following results:

Smashed into	Hit
$n = 15$	$n = 15$
$M = 40.8$	$M = 34.0$
$SS = 510$	$SS = 414$

   (a) Do the results indicate a significantly higher estimated speed for the "smashed into" group? Use a one-tailed test with $\alpha = 0.01$.

   (b) Compute Cohen's d to measure the size of the effect.

4. A researcher conducts an independent-measures study comparing two treatments and reports the t-statistic as $t(25) = 2.071$.

   (a) How many individuals participated in the entire study?

(b) Using a two-tailed test with $\alpha = 0.05$, is there a significant difference between the two treatments?

5. If other factors are held constant, explain how each of the following influences the value of the independent-measures t-statistic, the likelihood of rejecting the null hypothesis, and the magnitude of measures of effect size (e.g., Cohen's d).

   (a) Increasing the number of scores in each sample

   (b) Increasing the variance for each sample

9 Analysis of Variance

1. Explain why the F-ratio is expected to be near 1.00 when the null hypothesis is true.

2. A researcher reports an F-ratio with $df = 2, 27$ from an independent-measures research study.

   (a) How many treatment conditions were compared in the study?

   (b) What was the total number of participants in the study?

3. The following summary table presents the results from an ANOVA comparing four treatment conditions with $n = 10$ participants in each condition. Complete all missing values. *(Hint: start with the df column).*

Source	SS	df	MS	F
Between			10	
Within				
Total	174			

4. The following data were obtained from an independent-measures research study comparing three treatment conditions. Use an ANOVA with $\alpha = 0.05$ to determine whether there are any significant mean differences among the treatments.

Treatment 1	Treatment 2	Treatment 3
5	2	7
1	6	3
2	2	2
3	3	4
0	5	5
1	3	2
2	0	4
2	3	5

5. The following data were obtained from an independent-measures research study comparing three treatment conditions. Use an ANOVA with $\alpha = 0.05$ to determine whether there are any significant mean differences among the treatments.

Treatment 1	Treatment 2	Treatment 3	
$n = 8$	$n = 6$	$n = 4$	$N = 18$
$T = 16$	$T = 24$	$T = 32$	$G = 72$
$SS = 40$	$SS = 24$	$SS = 16$	$\sum X^2 = 464$

10 Answers to Selected Exercises

- Unit 1

1. population = all high school students in US; sample = 100 selected students
2. income = ratio (continuous); dependents = ratio (discrete); SSN = nominal (discrete)
3. DV = # of correct answers; discrete; ratio
4. numbers reflect an order; intervals between numbers make sense; ratios between numbers make sense
5. distribution is negatively skewed

X	f
10	1
11	2
12	2
13	4
14	6
15	5

6. distribution is negatively skewed

X	f
2	1
3	1
4	2
5	2
6	3
7	4
8	5
9	4
10	2

7. Width 5:

X	f
10-14	1
15-19	5
20-24	3
25-29	5
30-34	3
35-39	1
40-44	2
45-49	2
50-54	2

Width 10:

X	f
10-19	6
20-29	8
30-39	4
40-49	4
50-59	2

8. 5 points wide and around 7 intervals; 2 points wide and around 9 intervals; 10 points wide and around 8 intervals
9. bar graph typically has spaces between the bars, histograms have touching bars; bar graphs used for categorical data (ordinal/nominal), histograms used for interval/ratio data
10. you cannot see frequency of specific data points in a grouped table

- Unit 2
  1. mean = 4, median = 4.5, mode = 5
  2. mean = 2.79, median = 2.5, mode = 1
  3. mean = 8
  4. $\sum X = 96$
  5. $n = 5$
  6. mean = 18
  7. $SS = 80$; variance = 16, SD = 4
  8. range = 7, SD = 2.45; no change to either range or variability
  9. (across rows) 1.25, -1, 2, -0.5, 1.5, -0.75; (across rows) 72, 63, 78, 54, 45, 30
  10. 75, 90, 115, 130
- Unit 3
  1. $r = -0.58$
  2. $r = 0.83$
  3. $r = 0$
  4. $r = -0.83$
  5. $r = 0.5$; no change; no change
- Unit 4
  1. (a) 0.1056; (c) 0.7580
  2. (a) 0.1974; (c) 0.3539
  3. (a) z=-1.96; (c) $z = 0.38$
  4. (a) right, 0.4013; (c) left, 0.3085
  5. (a) 0.3085; (c) 0.6826
  6. (a) 0.1587; (c) 584
- Unit 5
  1. answers may vary
  2. (a) boundaries become larger; (b) decreases (be sure to explain why on both)

3. (a) increases; (b) decreases (be sure to explain why on both)
4. (a) H_0: memory score for participant = memory score for population; (b) $z_crit = \pm 1.96$, $z_{\text{participant}} = 1.17$, fail to reject H_0, conclude no effect of supplement
5. (a) not enough information (why?) (c) Researcher B fails to reject (why?);

- Unit 6

1. (a) No. $z = 1.5$, but $z_{\text{crit}} = \pm 1.96$, so cannot reject null; (b) Yes. $z = 3.0$, which is beyond z_{crit}, so reject null.
2. (a) Yes. $z = 4.0$, which is beyond $z_{\text{crit}} = \pm 1.96$, so reject null; (b) No. $z = 1.33$, which is less than z_{crit}, so cannot reject null.
3. (a) Yes. $z = 2.77$, which is beyond $z_{\text{crit}} = 2.33$, so reject null; (b) $d = 0.62$

- Unit 7

1. Yes, since $t(24) = 2.75$ exceeds $t_{\text{crit}} = 2.064$
2. (a) No, since $t(15) = 1.73$ does not exceed $t_{\text{crit}} = 2.131$; (b) Yes, since $t(35) = 2.60$ exceeds $t_{\text{crit}} = 2.03$.
3. Yes, since $t(15) = 8.20$ exceeds $t_{\text{crit}} = 2.947$
4. Yes, since $t(8) = 3.20$ exceeds $t_{\text{crit}} = 2.306$
5. (c) Yes, since $t(5) = 3.00$ exceeds $t_{\text{crit}} = 2.571$

- Unit 8

1. (a) 120; (b) 4; (c) No, $t = 2$, but for $df = 28$ we have $t_{\text{crit}} = \pm 2.048$
2. (a) Yes, $t(32) = -3.92$, which is beyond $t_{\text{crit}} = \pm 2.750$; (b) $d = -1.35$
3. (a) Yes, $t(28) = 3.24$, which is beyond $t_{\text{crit}} = 2.467$; (b) $d = 1.18$
4. (a) 27; (b) Yes, since $t_{\text{crit}} = \pm 2.060$

- Unit 9

1. use the definition of the F-ratio
2. (a) 3; (b) 30 (be sure to explain why)
3. $F = 2.50$
4. $F = 2.80$
5. $F = 9.00$