**Multiple Choice Questions**

1. For a one-way ANOVA comparing five conditions of the predictor, what is stated by the null hypothesis (*H*0)?

|  |  |
| --- | --- |
| a. | There are no differences between any of the population means. |
| b. | At least one of the five population means is different from another mean. |
| c. | All five of the population means are different from each other. |
| d. | None of the other choices is correct. |

2. For an ANOVA comparing three treatment conditions, what is stated by the alternative hypothesis (*H*1)?

|  |  |
| --- | --- |
| a. | There are no differences between any of the population means. |
| b. | At least one of the three population means is different from another mean. |
| c. | All three of the population means are different from each other. |
| d. | None of the other choices is correct. |

3. When comparing more than two conditions’ means, why should you use a one-way analysis of variance instead of using multiple *t* tests?

|  |  |
| --- | --- |
| a. | Using multiple *t* tests increases the risk of a Type I error. |
| b. | Using multiple *t* tests increases the risk of a Type II error. |
| c. | The analysis of variance is more likely to detect an effect of your predictor. |
| d. | There is no advantage to using an analysis of variance instead of multiple *t* tests. |

4. In a one-way analysis of variance, differences caused by going through different experimental conditions contribute to which of the following variances?

|  |  |
| --- | --- |
| a. | Both between-group variance and within-group variance |
| b. | Between-group variance but not within-group variance |
| c. | Within-group variance but not between-group variance |
| d. | Neither between-group variance nor within-group variance |

5. The following table resembles SPSS output and shows the results of an analysis of variance comparing four conditions of an IV, with a sample of *n* = 5 participants in each condition. What is the missing value for *SS*within?

|  |
| --- |
| Source *SS df MS* |
| Between 30 3 10 |
| Within XX 16 2 |
| Total 62 19 |

|  |  |
| --- | --- |
| a. | 2.1 |
| b. | 8 |
| c. | 18 |
| d. | 32 |

6. The following table shows the results of an analysis of variance comparing three treatment conditions with a sample of *n* = 10 participants in each treatment. Note that several values are missing in the table. What is the missing value for *MS*R(aka *MS*W)?

Source *SS df MS*

Between XX 2 10 *F* = 5.00

Within 54 27 XX

Total 74 XX

|  |  |
| --- | --- |
| a. | 0.50 |
| b. | 2 |
| c. | 50 |
| d. | 81 |

7. The following table shows the results of an analysis of variance comparing four treatment conditions with a sample of *n* = 11 participants in each treatment. What is the missing value for the *F*-ratio?

|  |  |
| --- | --- |
| a. | 0.50 Source *SS df MS* |
| b. | 2 Between 42 3 14 *F* = xx |
| c. | 7 Within 140 20 7 |
| d. | 21 Total 182 21 |

8. In an analysis of variance, which of the following is determined by the size of the sample mean differences across conditions?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | *SS*between | c. | Unsystematic variance |
| b. | *SS*within | d. | *MSR* |

9. In general, what factors are most likely to lead a researcher to conclude that the null hypothesis is *not* credible, when conducting an ANOVA?

|  |  |
| --- | --- |
| a. | Small mean differences and small unsystematic variances |
| b. | Small mean differences and large unsystematic variances |
| c. | Large mean differences and small unsystematic variances |
| d. | Large mean differences and large unsystematic variances |

10. What is the purpose of conducting follow-up tests to an ANOVA, like post-hoc tests or planned comparisons/contrasts?

|  |  |
| --- | --- |
| a. | To determine whether a Type I error was committed |
| b. | To determine how much difference exists between the conditions |
| c. | To determine which conditions are significantly different |
| d. | Both B and C |

11. All of the following are true of one-way ANOVA, except for:

|  |  |
| --- | --- |
| a. | it can be used with continuous predictors. |
| b. | it can be used with more than one predictor. |
| c. | it can be used to analyze data from experiments with more than one IV. |
| d. | it can be used with categorical predictors with more than 2 categories. |

12. For which research question would you NOT use an ANOVA for data analysis?

|  |  |
| --- | --- |
| a. | Which of four sports – baseball, basketball, football, or soccer – is most popular among teenagers? |
| b. | Do cats or dogs make better pets, and does it depend on whether the owner is an introvert or extrovert? |
| c. | Does a person’s year in school in HS (e.g., 9th grade vs. 10th grade, etc.) influence how many Advanced Placement classes they take? |
| d. | Does a person’s age influence whether they vote in an election? |

13. The output from an *F*-test itself can help us learn . . .

|  |  |
| --- | --- |
| a. | which conditions of our IV are different from which other conditions. |
| b. | which conditions of our IV have larger mean scores on the DV than which other conditions of our IV. |
| c. | whether using the grand mean of your sample is just as helpful as using individual group means to predict the outcome. |
| d. | whether two variables have a linear relationship. |

14. The *F*-test is called an “omnibus” test, suggesting that:

|  |  |
| --- | --- |
| a. | it can be used with predictors with 3+ categories. |
| b. | it is a particularly robust test with regard to violations of assumptions. |
| c. | it cannot be used for within-subjects designs. |
| d. | it tells us that there is a difference among the group means but isn’t able to specify where that difference lies. |

15. Which is FALSE with regard to the use of planned contrasts?

|  |  |
| --- | --- |
| a. | They require you to have hypotheses about which means (or subsets of means) will differ from one another. |
| b. | They involve comparing all possible pairs of means. |
| c. | They are more “confirmatory” in nature than “exploratory.” |
| d. | They are specified before the researcher even runs the study. |

16. If you are running planned contrasts for a study that involved four conditions, which of the following are possible comparisons you could make? *Note there are 5 choices.*

|  |  |
| --- | --- |
| a. | Compare condition 1 & 2 (combined) with condition 3 & 4 (combined) |
| b. | Compare condition 1 to condition 2. |
| c. | Compare condition 2 to condition 4. |
| d. | Compare conditions 1 and 2 (combined) to condition 3. |
| e. | Any/All of these are comparisons you could make with planned contrasts. |

**Indicate “True” or “False” for each statement. If False, explain why you think so and/or how to make the statement true.**

1. For an analysis of variance comparing three treatment means, *H*0 states that all three population means are the same and *H*1 states that all three population means are different.

2. An *F*-ratio < 1.00 is an indication that the null hypothesis is likely to be true, because the differences between the conditions of your IV is small relative to the differences within the groups.

3. The larger the differences among the group means, the larger the numerator of the *F*-ratio will be.

4. *SS*within measures the variability in the outcome that exists due to natural differences across participants, measurement error, and other sources of “noise.”

5. If an analysis of variance produces a value of *F* = 0, then all the groups/conditions have the same mean.

6. In analysis of variance, large variances within groups reduce the likelihood of rejecting the null hypothesis.

7. Post-hoc tests or planned contrasts are typically only needed if *H*0 is shown not to be credible in an ANOVA comparing more than two conditions.

8. An ANOVA is used to determine whether any significant difference exists between group means, and post-hoc tests or planned contrasts are used to determine exactly which group means are significantly different.

9. An *F*-ratio with a *p* = .54 suggests that there is no significant difference between group means.

10. Small *F*-ratios are more likely to be statistically significant.

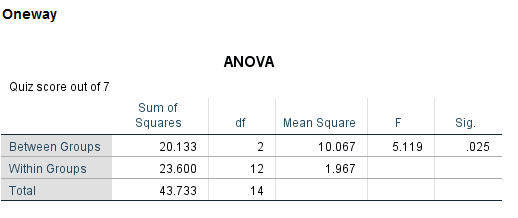
11. For exploratory research, researchers will most often use planned contrasts if their *F-*test yields a significant result.

12. If you typically use a .05 cut off for your *p*-value, a post-hoc test might involve using a *p*-value of .07, or .10, which is more stringent.

13. If you have a study with 1 predictor variable with 3 conditions, and one outcome variable and you plan to run a one-way ANOVA, your data file with have 4 variables.

14. *Use the table below for this question*.

True or False – The table shows that there is a significant difference in the means for the “between groups” condition and the “within groups” condition, *p* = .025.

****

**KEY**

1. A
2. B
3. A
4. B. Remember that one way of thinking about the *F* ratio for ANOVA is the ratio of between-group variability to within-group variability. (We discussed this in lecture, and you can see these terms “between” and “within” in the ANOVA table output from SPSS.) When a researcher manipulates a variable, creating multiple conditions of that variable, the researcher predicts to see differences *between* the different conditions/groups. So any differences caused by the different experimental conditions contributes to between-group variance.
5. D. (The SSwithin is the same concept as the SSR, and SSbetween is the same concept as the SSM. And we know that SSM + SSR = SST . In the problem SST = 62, so we subtract 30 to get the SSR, which is 32.
6. B The *MS*within is the same concept as the *MS*R, and the *MS*between is the same concept as the *MS*M. We also know that *F* = *MS*M /*MS*R OR *F* = *MS*between /*MS*within. Plugging the values from the table into this equation we get:

*F* = *MS*between /*MS*within 🡪 5.00 = 10 /*MS*within, which means that *MS*within, = 2.

1. B. *F* = *MS*between / *MS*within = 14/7 = 2.00. Remember from lecture that *MS*between is another way of writing *MS*M, and that*MS*within is another way of writing *MS*R.
2. A. The question is asking which answer choice is determined by how large the difference is between the means of the various groups/conditions of the predictor. The answer, SSbetween, refers to the variability explained by the experimental manipulation (by being in one group/condition of the manipulated variable vs. another).
3. C. The *F* ratio is the ratio of systematic variability (variability produced by the manipulation, by being in one group vs. another group) to unsystematic variability (variability produced by individual differences, or random other factors that just happened to cause different people to score differently). Choice C refers to large differences between the means of different groups (the numerator of the *F* ratio) and small unsystematic variances (the denominator). This combination of large mean differences and small unsystematic variances will produce a large *F* ratio, and consequently a smaller *p*-value. Smaller *p*-values lead us to conclude the null is *not* credible.
4. C. C is the best answer. You cannot know whether a Type I error was committed (answer A). B is not a good answer because you can understand how much difference exists between the conditions simply by looking at the Descriptives table that you run with the basic one-way ANOVA. You do not need to run follow-up tests to know how *much* difference there is between conditions; you need them in order to know whether that difference is statistically significant.
5. A. ANOVAs can only be run with categorical predictors. The outcome should be continuous, though.
6. D. This question involves a continuous predictor, and a categorical (yes/no) outcome. You cannot use an ANOVA for this type of data.
7. C.
8. D
9. B. Planned contrasts/comparisons don’t necessarily involve comparing every single pair of means. Instead, they involve comparing means (or subsets of means) for which you specifically have hypotheses about how they may differ. Post-hoc tests do involve comparing every single pair of means.
10. E

**True/False Answer Key (I explain the False answers, but also some of the True ones.)**

1. F. The problem with this statement is the second part, which is about *H*1. As discussed in class, when there are 3 conditions of the IV, there are multiple possible ways to state the alternative hypothesis and all must be included. It’s possible that: all three population means are different from one another, that the first mean is equal to the third mean but both are different from the second mean, that the second mean is equal to the third mean, but both are different from the first, and that the first mean is equal to the second mean but both are different from the third mean.

2. T

3. T

4. T

5. T. If *F* = 0, it means the numerator of the F-ratio = 0. Remember that the numerator of the F- ratio is a value that captures the amount of variability in your outcome variable that is due to being in one group/condition versus another. If the numerator is 0, it means there is *no* variability that is caused by being in one group versus another; all the existing variability in the outcome stems from error. Another way to think about this is that the numerator for F is the between-groups variance. If *F* = 0, it means the between-groups variance equals 0, which means there are zero differences between the groups’ means (i.e., all the groups/conditions have the same mean).

6. T. Remember that within-group variance makes up the denominator of the F-ratio. If your within-group variance is large, it means that your F-ratio will be small (holding all else constant). If your F ratio is small, it means your p-value will be large (*p* **>** .05), which means the null is credible. If the null is credible, it means you’ll accept the null (rather than reject the null).

7. T

8. T

9. T

10. F. Large *F*-ratios occur when the model is good, and are more likely to be statistically significant (than small ratios). A large *F-*ratio implies that the size of the differences between groups/conditions is large relative to the unsystematic variance in the data. Whenever the difference between group means is large relative to the error in the data, we are more likely to conclude that the null hypothesis (which specifies there are NO differences in group means) is *not* credible.

11. F. For exploratory research, researchers usually use post-hoc tests rather than planned contrasts/comparisons. You use post-hoc tests if you do not have hypotheses ahead of time. Exploratory research implies that you are investigating a research question that has not been studied very much, and therefore you do not have a strong existing literature to draw on for any hypotheses, so you do not specify any hypotheses.

12. F. Post-hoc tests use a stricter (more stringent) criterion to accept an effect as significant, which means a post-hoc test will in theory *lower* the cut off, from .05 to something like .02, or .005. Your *p*-value must be lower than this new cut off to conclude that there is a significant difference between means. Raising the cut-off to *p* = .07 means that you are making the criteria for significance LESS stringent.

13. F. Your data file will have TWO variables – one variable that captures Ps’ scores on the outcome and one variable that captures which of the 3 conditions each participant is in (i.e., one variable for the IV and one for the DV).

14. F. The table simply shows that there is *a* difference between some of the group means. “Between” and “Within” are *not* the names of the conditions; they are ways to characterize the different forms of variability in your outcome variable. (The predictor/IV and the condition names and means do not appear in the ANOVA table.)