***Please show all of your work so that we have the option of giving you partial credit for your work. Please circle your final answers. Make a copy of your calculations and answers so you will be able to check your answers when the answer key is posted on the class website after the testing period has ended. Please use Blue Books provided.***

1. A sleep researcher conducts an experiment to determine if sleep loss affects ability to maintain sustained attention. Fifteen subjects are randomly assigned to the following three groups of 5 subjects each: group 1, which gets the normal amount of sleep (7-8 hours), group 2, which is sleep-deprived for 24 hours; and group 3, which is sleep-deprived for 48 hours. All three groups are tested on the same auditory vigilance task. Subjects are presented with half-second tones spaced at irregular intervals over a 30-minute duration. Occasionally, one of the tones is slightly shorter than the rest. The subject's task is to detect the shorter tones. Ten shorter tones were presented. The following table indicates the number of shorter tones correctly detected (a higher score means better performance).

| Normal Sleep | Sleep-Deprived for 24 hours | Sleep-Deprived for 48 hours |
|---|---|---|
| 10 | 5 | 5 |
| 9 | 4 | 2 |
| 8 | 3 | 1 |
| 7 | 4 | 2 |
| 8 | 7 | 3 |

a. State the scientific hypothesis and the PCH (plausible competing hypothesis) of chance (5 points).

b. Translate the scientific hypothesis and the PCH of chance to statistical hypotheses – that is state $H_0$ and $H_1$ (2 points).

c. Name the test statistic you will use to decide between the statistical hypotheses (5 points).

d. Does the issue of one-tailed versus two-tailed statistical hypotheses apply to this test? (yes/no) (2 points).

e. What is the alpha level (level of significance or p-value) you will use? (2 points).

1f. Calculate the degrees of freedom (df) you will use for your critical value (or values) (4 points).

1g. What is the critical value (or values)? (2 points).

1h. Draw a line representing the range of your statistic. What is the value predicted by $H_0$? Draw it on the line. Also draw the critical value (or values) on the line. Label the "Reject $H_0$" region (or regions). Label the "Do not Reject $H_0$" region. (5 points).

1i. Find the means of the three groups and graph them (5 points).

1j. Does the pattern of the data fit the scientific hypothesis? Why or why not ? (2 points).

1k. Calculate the value of your test statistic from the data. Graph this on your number line in part h. Does it fall in the rejection region(s)? (10 points).

1l. Do you reject $H_o$ or not? (3 points).

1m. What do the results indicate regarding the relationship between sleep loss and the ability to maintain sustained attention. (4 points).

2 A store manager wants to determine if newspaper advertising really does affect sales. He randomly selects 10 items currently in stock and proceeds to establish a baseline by counting the number of each item sold over a 1-week period. Then, without changing the price of the items, he places a large ad in the newspaper, advertising the 10 items. Again, he counts the number of each item sold over a 1-week period. The number of items sold over the two 1-week periods are listed below:

| Item # | Number sold before the ad | Number sold after the ad |
|---|---|---|
| 1 | 25 | 32 |
| 2 | 18 | 24 |
| 3 | 3 | 7 |
| 4 | 16 | 18 |
| 5 | 20 | 25 |
| 6 | 23 | 20 |
| 7 | 10 | 15 |
| 8 | 25 | 23 |
| 9 | 32 | 34 |
| 10 | 15 | 15 |

a. State the scientific hypothesis and the PCH (plausible competing hypothesis) of chance (5 points).

b. Is the scientific hypothesis directional or nondirectional? Why? (2 points).

c. Name the test statistic you will use to decide between the statistical hypotheses (5 points).

d. Translate the scientific hypothesis and the PCH of chance to statistical hypotheses – that is state $H_0$ and $H_1$ (2 points).

e. What is the alpha level (level of significance or p-value) you will use? (2 points).

f. In your own words, what does the alpha level mean? (3 points).

g. Calculate the degrees of freedom (df) you will use for your critical value (or values) (4 points).

h. What is the critical value (or values)? (2 points).

i. Draw a line representing the range of your statistic. What is the value predicted by $H_0$? Draw it on the line. Also draw the critical value (or values) on the line. Label the "Reject $H_0$" region (or regions). Label the "Do not Reject $H_0$" region. (5 points).

j. Does the pattern of the data fit the scientific hypothesis? Why or why not ? (2 points).

k. Calculate the value of your test statistic from the data. Graph this on your number line in part i. Does it fall in the rejection region(s)? (10 points).

l. Do you reject $H_o$ or not? (3 points).

m. What do the results indicate regarding the relationship between advertising and product sales. (4 points).

**t-table**

| | one-tailed | 0.05 | 0.025 | 0.01 | 0.005 | 0.001 |
|---|---|---|---|---|---|---|
| | two-tailed | 0.1 | 0.05 | 0.02 | 0.01 | 0.002 |
| **df** | | | | | | |
| **1** | | 6.314 | 12.706 | 31.821 | 63.657 | 318.310 |
| **2** | | 2.920 | 4.303 | 6.965 | 9.925 | 22.326 |
| **3** | | 2.353 | 3.182 | 4.541 | 5.841 | 10.213 |
| **4** | | 2.132 | 2.776 | 3.747 | 4.604 | 7.173 |
| **5** | | 2.015 | 2.571 | 3.365 | 4.032 | 5.893 |
| **6** | | 1.943 | 2.447 | 3.143 | 3.707 | 5.208 |
| **7** | | 1.895 | 2.365 | 2.998 | 3.499 | 4.785 |
| **8** | | 1.86 | 2.306 | 2.896 | 3.355 | 4.501 |
| **9** | | 1.833 | 2.262 | 2.821 | 3.250 | 4.297 |
| **10** | | 1.812 | 2.228 | 2.764 | 3.169 | 4.144 |
| **11** | | 1.796 | 2.201 | 2.718 | 3.106 | 4.025 |
| **12** | | 1.782 | 2.179 | 2.681 | 3.055 | 3.930 |
| **13** | | 1.771 | 2.160 | 2.650 | 3.012 | 3.852 |
| **14** | | 1.761 | 2.145 | 2.624 | 2.977 | 3.787 |
| **15** | | 1.753 | 2.131 | 2.602 | 2.947 | 3.733 |
| **16** | | 1.746 | 2.120 | 2.583 | 2.921 | 3.686 |
| **17** | | 1.74 | 2.110 | 2.567 | 2.898 | 3.646 |
| **18** | | 1.734 | 2.101 | 2.552 | 2.878 | 3.610 |
| **19** | | 1.729 | 2.093 | 2.539 | 2.861 | 3.579 |
| **20** | | 1.725 | 2.086 | 2.528 | 2.845 | 3.552 |
| **21** | | 1.721 | 2.080 | 2.518 | 2.831 | 3.527 |
| **22** | | 1.717 | 2.074 | 2.508 | 2.819 | 3.505 |
| **23** | | 1.714 | 2.069 | 2.500 | 2.807 | 3.485 |
| **24** | | 1.711 | 2.064 | 2.492 | 2.797 | 3.467 |
| **25** | | 1.708 | 2.060 | 2.485 | 2.787 | 3.450 |
| **26** | | 1.706 | 2.056 | 2.479 | 2.779 | 3.435 |
| **27** | | 1.703 | 2.052 | 2.473 | 2.771 | 3.421 |
| **28** | | 1.701 | 2.048 | 2.467 | 2.763 | 3.408 |
| **29** | | 1.699 | 2.045 | 2.462 | 2.756 | 3.396 |
| **30** | | 1.697 | 2.042 | 2.457 | 2.750 | 3.385 |
| **40** | | 1.684 | 2.021 | 2.423 | 2.704 | 3.307 |
| **60** | | 1.671 | 2.000 | 2.390 | 2.660 | 3.232 |
| **120** | | 1.658 | 1.980 | 2.358 | 2.617 | 3.160 |
| **inf** | | 1.645 | 1.960 | 2.326 | 2.576 | 3.090 |

Chi-squared table

| | one-tailed | 0.050 | 0.010 | 0.001 |
|---|---|---|---|---|
| **df** | | | | |
| 1 | | 3.84146 | 6.63490 | 10.828 |
| 2 | | 5.99147 | 9.21034 | 13.816 |
| 3 | | 7.81473 | 11.3449 | 16.266 |
| 4 | | 9.48773 | 13.2767 | 18.467 |
| 5 | | 11.0705 | 15.0863 | 20.515 |
| 6 | | 12.5916 | 16.8119 | 22.458 |
| 7 | | 14.0671 | 18.4753 | 24.322 |
| 8 | | 15.5073 | 20.0902 | 26.125 |
| 9 | | 16.9190 | 21.6660 | 27.877 |
| 10 | | 18.3070 | 23.2093 | 29.588 |
| 11 | | 19.6751 | 24.7250 | 31.264 |
| 12 | | 21.0261 | 26.2170 | 32.909 |
| 13 | | 22.3621 | 27.6883 | 34.528 |
| 14 | | 23.6848 | 29.1413 | 36.123 |
| 15 | | 24.9958 | 30.5779 | 37.697 |
| 16 | | 26.2962 | 31.9999 | 39.252 |
| 17 | | 27.5871 | 33.4087 | 40.790 |
| 18 | | 28.8693 | 34.8053 | 42.312 |
| 19 | | 30.1435 | 36.1908 | 43.820 |
| 20 | | 31.4104 | 37.5662 | 45.315 |
| 21 | | 32.6705 | 38.9321 | 46.797 |
| 22 | | 33.9244 | 40.2894 | 48.268 |
| 23 | | 35.1725 | 41.6384 | 49.728 |
| 24 | | 36.4151 | 42.9798 | 51.179 |
| 25 | | 37.6525 | 44.3141 | 52.620 |
| 26 | | 38.8852 | 45.6417 | 54.052 |
| 27 | | 40.1133 | 46.9630 | 55.476 |
| 28 | | 41.3372 | 48.2782 | 56.892 |
| 29 | | 42.5569 | 49.5879 | 58.302 |
| 30 | | 43.7729 | 50.8922 | 59.703 |
| 40 | | 55.7585 | 63.6907 | 73.402 |
| 50 | | 67.5048 | 76.1539 | 86.661 |
| 60 | | 79.0819 | 88.3794 | 99.607 |
| 70 | | 90.5312 | 100.425 | 112.317 |
| 80 | | 101.879 | 112.329 | 124.839 |
| 90 | | 113.145 | 124.116 | 137.208 |
| 100 | | 124.342 | 135.807 | 149.449 |

**F table**

**alpha =.05**

| | *df upper* | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **12** | **15** | **20** | **24** | **30** | **40** | **60** | **120** | **inf** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *df lower* | | | | | | | | | | | | | | | | | | | | |
| **1** | | 161.4 | 199.5 | 215.7 | 224.6 | 230.2 | 234.0 | 236.8 | 238.9 | 240.5 | 241.9 | 243.9 | 245.9 | 248.0 | 249.1 | 250.1 | 251.1 | 252.2 | 253.3 | 254.3 |
| **2** | | 18.51 | 19.00 | 19.16 | 19.25 | 19.30 | 19.33 | 19.35 | 19.37 | 19.38 | 19.40 | 19.41 | 19.43 | 19.45 | 19.45 | 19.46 | 19.47 | 19.48 | 19.49 | 19.50 |
| **3** | | 10.13 | 9.55 | 9.28 | 9.12 | 9.01 | 8.94 | 8.89 | 8.85 | 8.81 | 8.79 | 8.74 | 8.70 | 8.66 | 8.64 | 8.62 | 8.59 | 8.57 | 8.55 | 8.53 |
| **4** | | 7.71 | 6.94 | 6.59 | 6.39 | 6.26 | 6.16 | 6.09 | 6.04 | 6.00 | 5.96 | 5.91 | 5.86 | 5.80 | 5.77 | 5.75 | 5.72 | 5.69 | 5.66 | 5.63 |
| **5** | | 6.61 | 5.79 | 5.41 | 5.19 | 5.05 | 4.95 | 4.88 | 4.82 | 4.77 | 4.74 | 4.68 | 4.62 | 4.56 | 4.53 | 4.50 | 4.46 | 4.43 | 4.40 | 4.36 |
| **6** | | 5.99 | 5.14 | 4.76 | 4.53 | 4.39 | 4.28 | 4.21 | 4.15 | 4.10 | 4.06 | 4.00 | 3.94 | 3.87 | 3.84 | 3.81 | 3.77 | 3.74 | 3.70 | 3.67 |
| **7** | | 5.59 | 4.74 | 4.35 | 4.12 | 3.97 | 3.87 | 3.79 | 3.73 | 3.68 | 3.64 | 3.57 | 3.51 | 3.44 | 3.41 | 3.38 | 3.34 | 3.30 | 3.27 | 3.23 |
| **8** | | 5.32 | 4.46 | 4.07 | 3.84 | 3.69 | 3.58 | 3.50 | 3.44 | 3.39 | 3.35 | 3.28 | 3.22 | 3.15 | 3.12 | 3.08 | 3.04 | 3.01 | 2.97 | 2.93 |
| **9** | | 5.12 | 4.26 | 3.86 | 3.63 | 3.48 | 3.37 | 3.29 | 3.23 | 3.18 | 3.14 | 3.07 | 3.01 | 2.94 | 2.90 | 2.86 | 2.83 | 2.79 | 2.75 | 2.71 |
| **10** | | 4.96 | 4.10 | 3.71 | 3.48 | 3.33 | 3.22 | 3.14 | 3.07 | 3.02 | 2.98 | 2.91 | 2.85 | 2.77 | 2.74 | 2.70 | 2.66 | 2.62 | 2.58 | 2.54 |
| **11** | | 4.84 | 3.98 | 3.59 | 3.36 | 3.20 | 3.09 | 3.01 | 2.95 | 2.90 | 2.85 | 2.79 | 2.72 | 2.65 | 2.61 | 2.57 | 2.53 | 2.49 | 2.45 | 2.40 |
| **12** | | 4.75 | 3.89 | 3.49 | 3.26 | 3.11 | 3.00 | 2.91 | 2.85 | 2.80 | 2.75 | 2.69 | 2.62 | 2.54 | 2.51 | 2.47 | 2.43 | 2.38 | 2.34 | 2.30 |
| **13** | | 4.67 | 3.81 | 3.41 | 3.18 | 3.03 | 2.92 | 2.83 | 2.77 | 2.71 | 2.67 | 2.60 | 2.53 | 2.46 | 2.42 | 2.38 | 2.34 | 2.30 | 2.25 | 2.21 |
| **14** | | 4.60 | 3.74 | 3.34 | 3.11 | 2.96 | 2.85 | 2.76 | 2.70 | 2.65 | 2.60 | 2.53 | 2.46 | 2.39 | 2.35 | 2.31 | 2.27 | 2.22 | 2.18 | 2.13 |
| **15** | | 4.54 | 3.68 | 3.29 | 3.06 | 2.90 | 2.79 | 2.71 | 2.64 | 2.59 | 2.54 | 2.48 | 2.40 | 2.33 | 2.29 | 2.25 | 2.20 | 2.16 | 2.11 | 2.07 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **16** | | 4.49 | 3.63 | 3.24 | 3.01 | 2.85 | 2.74 | 2.66 | 2.59 | 2.54 | 2.49 | 2.42 | 2.35 | 2.28 | 2.24 | 2.19 | 2.15 | 2.11 | 2.06 | 2.01 |
| **17** | | 4.45 | 3.59 | 3.20 | 2.96 | 2.81 | 2.70 | 2.61 | 2.55 | 2.49 | 2.45 | 2.38 | 2.31 | 2.23 | 2.19 | 2.15 | 2.10 | 2.06 | 2.01 | 1.96 |
| **18** | | 4.41 | 3.55 | 3.16 | 2.93 | 2.77 | 2.66 | 2.58 | 2.51 | 2.46 | 2.41 | 2.34 | 2.27 | 2.19 | 2.15 | 2.11 | 2.06 | 2.02 | 1.97 | 1.92 |
| **19** | | 4.38 | 3.52 | 3.13 | 2.90 | 2.74 | 2.63 | 2.54 | 2.48 | 2.42 | 2.38 | 2.31 | 2.23 | 2.16 | 2.11 | 2.07 | 2.03 | 1.98 | 1.93 | 1.88 |
| **20** | | 4.35 | 3.49 | 3.10 | 2.87 | 2.71 | 2.60 | 2.51 | 2.45 | 2.39 | 2.35 | 2.28 | 2.20 | 2.12 | 2.08 | 2.04 | 1.99 | 1.95 | 1.90 | 1.84 |
| **21** | | 4.32 | 3.47 | 3.07 | 2.84 | 2.68 | 2.57 | 2.49 | 2.42 | 2.37 | 2.32 | 2.25 | 2.18 | 2.10 | 2.05 | 2.01 | 1.96 | 1.92 | 1.87 | 1.81 |
| **22** | | 4.30 | 3.44 | 3.05 | 2.82 | 2.66 | 2.55 | 2.46 | 2.40 | 2.34 | 2.30 | 2.23 | 2.15 | 2.07 | 2.03 | 1.98 | 1.94 | 1.89 | 1.84 | 1.78 |
| **23** | | 4.28 | 3.42 | 3.03 | 2.80 | 2.64 | 2.53 | 2.44 | 2.37 | 2.32 | 2.27 | 2.20 | 2.13 | 2.05 | 2.01 | 1.96 | 1.91 | 1.86 | 1.81 | 1.76 |
| **24** | | 4.26 | 3.40 | 3.01 | 2.78 | 2.62 | 2.51 | 2.42 | 2.36 | 2.30 | 2.25 | 2.18 | 2.11 | 2.03 | 1.98 | 1.94 | 1.89 | 1.84 | 1.79 | 1.73 |
| **25** | | 4.24 | 3.39 | 2.99 | 2.76 | 2.60 | 2.49 | 2.40 | 2.34 | 2.28 | 2.24 | 2.16 | 2.09 | 2.01 | 1.96 | 1.92 | 1.87 | 1.82 | 1.77 | 1.71 |
| **26** | | 4.23 | 3.37 | 2.98 | 2.74 | 2.59 | 2.47 | 2.39 | 2.32 | 2.27 | 2.22 | 2.15 | 2.07 | 1.99 | 1.95 | 1.90 | 1.85 | 1.80 | 1.75 | 1.69 |
| **27** | | 4.21 | 3.35 | 2.96 | 2.73 | 2.57 | 2.46 | 2.37 | 2.31 | 2.25 | 2.20 | 2.13 | 2.06 | 1.97 | 1.93 | 1.88 | 1.84 | 1.79 | 1.73 | 1.67 |
| **28** | | 4.20 | 3.34 | 2.95 | 2.71 | 2.56 | 2.45 | 2.36 | 2.29 | 2.24 | 2.19 | 2.12 | 2.04 | 1.96 | 1.91 | 1.87 | 1.82 | 1.77 | 1.71 | 1.65 |
| **29** | | 4.18 | 3.33 | 2.93 | 2.70 | 2.55 | 2.43 | 2.35 | 2.28 | 2.22 | 2.18 | 2.10 | 2.03 | 1.94 | 1.90 | 1.85 | 1.81 | 1.75 | 1.70 | 1.64 |
| **30** | | 4.17 | 3.32 | 2.92 | 2.69 | 2.53 | 2.42 | 2.33 | 2.27 | 2.21 | 2.16 | 2.09 | 2.01 | 1.93 | 1.89 | 1.84 | 1.79 | 1.74 | 1.68 | 1.62 |
| **40** | | 4.08 | 3.23 | 2.84 | 2.61 | 2.45 | 2.34 | 2.25 | 2.18 | 2.12 | 2.08 | 2.00 | 1.92 | 1.84 | 1.79 | 1.74 | 1.69 | 1.64 | 1.58 | 1.51 |
| **60** | | 4.00 | 3.15 | 2.76 | 2.53 | 2.37 | 2.25 | 2.17 | 2.10 | 2.04 | 1.99 | 1.92 | 1.84 | 1.75 | 1.70 | 1.65 | 1.59 | 1.53 | 1.47 | 1.39 |
| **120** | | 3.92 | 3.07 | 2.68 | 2.45 | 2.29 | 2.17 | 2.09 | 2.02 | 1.96 | 1.91 | 1.83 | 1.75 | 1.66 | 1.61 | 1.55 | 1.50 | 1.43 | 1.35 | 1.25 |
| **inf** | | 3.84 | 3.00 | 2.60 | 2.37 | 2.21 | 2.10 | 2.01 | 1.94 | 1.88 | 1.83 | 1.75 | 1.67 | 1.57 | 1.52 | 1.46 | 1.39 | 1.32 | 1.22 | 1.00 |

**END OF EXAM**

* Remember, when checking your score, your answers will be graded based on your prior responses. For example, if you answered that Question 1 is directional, you will lose a few points, but all other answers will be graded assuming that this is correct.

# Final Form 1 answer key

## Psychology 3000-090 - Online Statistics

5pts 1 a The scientific hypothesis is that sleep loss effects ability to maintain sustained attention.
The $H_0$ of chance is that sleep loss has no effect on ability to maintain sustained attention or that any difference is due to chance alone

2pts b $H_0: E(\alpha_j) = 0$ for all $j$
$H_1: E(\alpha_j) \neq 0$ for some $j$

5pts c One-way ANOVA for independant means

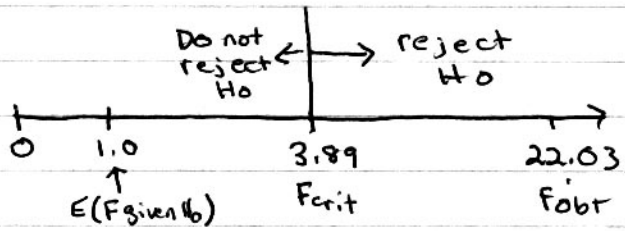
2pts d no

2pts e alpha $< .05$ OR $p < .05$

4pts f $df_{BG} = J - 1 = 3 - 1 = 2$
$df_{WG} = N - J = 15 - 3 = 12$

2pts g $f_{crit}(2,12)_{.05} = 3.89$

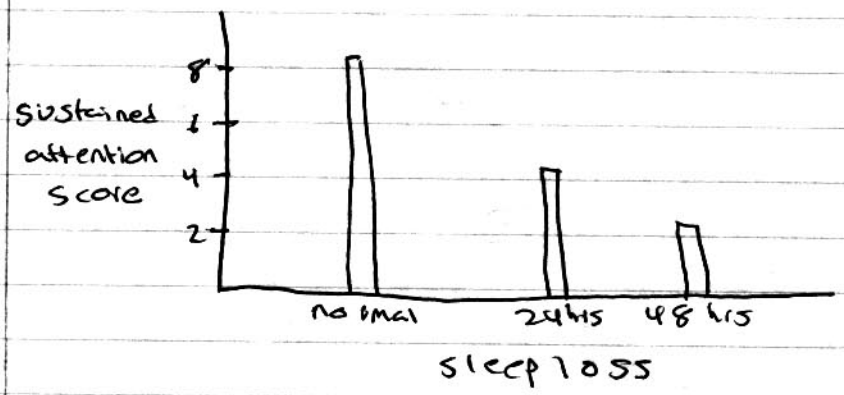
5pts h



5 pts i

| Normal | 24 hrs | 48 hrs |
|---|---|---|
| 10 | 5 | 5 |
| 9 | 4 | 2 |
| 8 | 3 | 1 |
| 7 | 4 | 2 |
| 8 | 7 | 3 |
| $\Sigma X =$ 42 | 23 | 13 |
| $M_X =$ 8.4 | 4.6 | 2.6 |

$\Sigma X_{ij} = 78$




2 pts j Yes, subjects with normal sleep scored highest, followed by those who were sleep deprived for 24 hours, with those sleep deprived for 48 hours performing worst

10 pts k $SS_{BG} = \sum_j \left[ \frac{\left(\sum_i X_{ij}\right)^2}{n_j} \right] - \frac{\left(\sum_j \sum_i X_{ij}\right)^2}{N}$

$= \left[ \frac{42^2}{5} + \frac{23^2}{5} + \frac{13^2}{5} \right] - \frac{78^2}{15}$

$= \frac{2462}{5} - \frac{6084}{15}$

$= 492.4 - 405.6$

$= 86.8$

$$SS_{WG} = \sum_j \sum_i X_{ij}^2 - \sum_i \left[ \frac{(\sum_i X_{ij})^2}{n_j} \right]$$

| NS | $X^2$ | 24 hrs | $X^2$ | 48 hrs | $X^2$ |
|---|---|---|---|---|---|
| 10 | 100 | 5 | 25 | 5 | 25 |
| 9 | 81 | 4 | 16 | 2 | 4 |
| 8 | 64 | 3 | 9 | 1 | 1 |
| 7 | 49 | 4 | 16 | 2 | 4 |
| 8 | 64 | 7 | 49 | 3 | 9 |
| | 358 | | 115 | | 43 |

Tot $\Sigma X^2 = 516$

$SS_{WG} = 516 - 492.4 = 23.6$

$MS_{BG} = \frac{SS_{BG}}{df_{BG}} = \frac{86.8}{2} = 43.4$

$MS_{WG} = \frac{SS_{WG}}{df_{WG}} = \frac{23.6}{12} = 1.97$

$F = \frac{MS_{BG}}{MS_{WG}} = \frac{43.4}{1.97} = 22.03$

F falls within the rejection region

3 pts L. Reject Ho

4 pts M. This suggests that the relationship between sleep loss and performance on a sustained attention task is not due to chance alone.

5pts 2 a. The scientific hypothesis is that newspaper advertising affects sales
The PCH of chance is that newspaper advertising has no affect on sales or that any change is due to chance alone.

2 pts b. nondirectional.

5 pts c. t-correlated

2 pts d. $H_0$: $E(M_D = 0)$
$H_1$: $E(M_D \neq 0)$

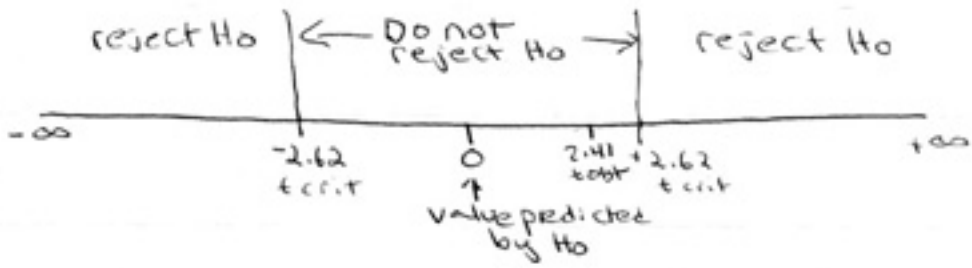
2pts e. alpha $< .05$ or $p < .05$

3 pts f. The aeceptable probability level that the observed difference is due to sampling error or chance

4 pts g. $df = N-1 = 10-1 = 9$

2 pts h. $t_{crit} = \pm 2.62$

5 pts i.




2 pts j. yes, the data pattern fits the scientific hypothesis. Sales are higher after advertising than before.

10 pts k.

| | before ad | after ad | difference (after - before) | $d^2$ |
|---|---|---|---|---|
| 1 | 25 | 32 | 7 | 49 |
| 2 | 18 | 24 | 6 | 36 |
| 3 | 3 | 7 | 4 | 16 |
| 4 | 16 | 18 | 2 | 4 |
| 5 | 20 | 25 | 5 | 25 |
| 6 | 23 | 20 | -3 | 9 |
| 7 | 10 | 15 | 5 | 25 |
| 8 | 25 | 23 | -2 | 4 |
| 9 | 32 | 34 | 2 | 4 |
| 10 | 15 | 15 | 0 | 0 |
| | | | 26 | 172 |

$M_d = 26/10 = 2.6$

$s_d = \sqrt{\frac{\Sigma d^2}{N_d} - (M_d)^2}$

$= \sqrt{\frac{172}{10} - (2.6)^2}$

$= \sqrt{17.2 - 6.76}$

$= \sqrt{10.44}$

$= 3.231$

$t = \frac{M_d}{s_d / \sqrt{N_d - 1}}$

$= \frac{2.6}{3.231/\sqrt{10-1}}$

$= \frac{2.6}{3.231/3}$

$= 2.6/1.077$

$= 2.41$

Do not reject Ho

3 pts | l. do not reject Ho

4 pts | m. The results indicate that the difference between sales before and after advertising could be explained by chance alone.