Stating results: general guidelines

When stating results, consider these items as a checklist:

• State what was evaluated (comparing means or variances, correlation of two variables, slope relating two variables, etc.). This will typically be the subject of the sentence.

• State the result to make the pattern clear to a reader. For example, state that one mean (or variance) is larger than the other; don't just say they are different.

• State the variables that were involved.

• Provide numerical support, typically the estimate and the confidence interval. Unless specifically asked for, do not report the *p*-value.

• Include units if the values being reported have them.

• Be succinct. Succinct doesn't just mean short; it means the answer is complete but no longer than needed.

Question #1

You want to evaluate whether **vanadium** concentrations are greater in **treated** or **untreated** samples. Using the R output results, succinctly state in one sentence what you can conclude, parenthetically supporting your answer quantitatively. A typical value of vanadium in the data set would be reported as 3.69 ppm.

```
  Welch Two Sample t-test

data:  vanadium[untreated] and vanadium[treated]
t = 9.0993, df = 74.776, p-value = 9.89e-14
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 3.452047 5.387352
sample estimates:
mean of x mean of y
10.010811  5.591111
```

Best answer: Mean vanadium concentrations are 4.4 ppm lower in treated samples than in untreated samples (95% CI: 3.45–5.39 ppm).

Less acceptable answer: Mean vanadium concentrations in untreated samples (10.0 ppm) are greater than in untreated samples (5.59 ppm; 95% CI on the difference in means: 3.45–5.39 ppm)

Why: This specifies that mean vanadium concentrations are what are being tested. It states the difference in means and whether it is higher in the untreated or treated samples. It ends with a confidence interval describing how well we can constrain the mean vanadium concentration. Because the confidence interval doesn't include zero, the reader knows that the result is statistically significant. It includes the units for the estimate and the confidence interval.

The answer is succinct: it covers all of these points in only 14 words.

Anything that does not cover these points and cover them succinctly would be less desirable. Any statement about statistical significance is not useful because the only thing statistical significance indicates here is that you are sure the difference in means is not zero, which doesn't help someone understand the difference in means or how well it is known. The *p*-

value should not be included as it adds nothing that isn't already conveyed by the confidence interval. Assume the reader is knowledgeable enough to know that this result is statistically significant based on the confidence interval.

The second answer is less acceptable because it forces the reader to calculate the difference in means. It also forces a more complicated wording of what the 95% CI is based on.

Question #2

Using the same vanadium data, you are testing whether the variance in **`vanadium`** is different in **`untreated`** or **`treated`** samples. Using the R results below, succinctly state in one sentence what you can conclude, parenthetically supporting your answer quantitatively.

```
  F test to compare two variances

data:  vanadium[untreated] and vanadium[treated]
F = 1.1424, num df = 36, denom df = 44, p-value = 0.6688
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.613367 2.171215
sample estimates:
ratio of variances
          1.142443
```

Best answer: The variance in vanadium concentrations is detectably greater in untreated samples than in treated samples (F=1.14, 95% C.I.: 0.61–2.17).

Why: This focuses on the test, which compares variances. Rather than describe it in terms of the ratio, this states which samples had the greater variance. The F-ratio and its confidence interval are reported parenthetically so the reader can see the comparison of variances; assume the reader is knowledgeable enough to know what an F-ratio is. Because F is a ratio, no units need to be reported.

Note that the statement does not say the variances are different, as we already know that because two groups of anything are assuredly different. Because the null hypothesis (identical variances) is false, we automatically know that we will either correctly reject the null (if our sample size is large enough) or make a type II error and accept the false null (if our sample size is too small). Therefore, the issue is not whether they are different but whether we can detect the difference. Here we have, and that's how we describe it.

The *p*-value is not the issue here, as it evaluates only whether the two variances are identical. It is much better to report the confidence interval because it describes how well you know the ratio of variances.

Question #3

Another study reported that the ratio of variances in vanadium between untreated and treated samples is typically around 1.9. Using the table above, state in one sentence whether your results are consistent with that hypothesis and parenthetically provide the necessary numerical support.

Best answer: The hypothesized ratio of variances (1.9) is consistent with our results (F=1.14, 95% C.I.: 0.61–2.17).

Why: It states the hypothesis and says it is consistent with our results. You could word it the other way around, but it would cause the sentence to be more complicated. State results simply. It also reports our numerical results, including our estimate of the ratio of variances and its confidence interval.

Question #4

You are studying the effects of salinity on the abundance of copepods (a crustacean). You've measured both to three significant figures. You have also tested their correlation; the R output is below. Describe the correlation in one sentence, followed by the necessary numerical support in parentheses. Your description should state whether the relationship is positive or negative, and whether it is strong, moderate, or weak.

```
  Pearson's product-moment correlation

data:  salinity and copepod
t = -4.9153, df = 40, p-value = 1.55e-05
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 -0.7733446 -0.3807232
sample estimates:
       cor
-0.6136472
```

Best answer: The correlation of salinity and the abundance of copepods is moderately negative (r=-0.61, 95% CI: -0.77 – -0.38).

Why: The subject of the sentence is what was tested, the correlation of salinity and the abundance of copepods. It describes the correlation: it is moderate and negative. It reports the correlation and its confidence intervals in parentheses.

The *p*-value is irrelevant: it tells us nothing that isn't already conveyed by the confidence interval. Because the confidence interval doesn't bracket the null hypothesis of zero, we know the result is statistically significant. Moreover, we do not need to say that the result is statistically significant; we can assume that the reader is knowledgeable enough to know that from the confidence interval.

Question #5

State in one sentence whether the correlation above is statistically significant, parenthetically adding the necessary numerical support.

Best answer: The correlation of salinity and the abundance of copepods is statistically significant (r=-0.61, 95% CI: -0.77– -0.38).

Less acceptable answer: The correlation of salinity and the abundance of copepods is statistically significant (t=-4.9, df=40, $p=10^{-5}$).

Why: Statistical significance is what is asked for, so we need to address it. Again, the subject of the sentence is what was tested. We state simply that it is statistically significant, and we report the test results in parentheses. The best answer is preferred because it reports the correlation coefficient and its uncertainty, whereas the t-test of R doesn't even report what the correlation is, making it less acceptable and less informative.

Question #6

You performed a linear regression with the same salinity and copepod data, and the R results are shown below. Using this, report the percentage of the variation in the number of copepods explained by salinity.

```
 Call:
lm(formula = copepod ~ salinity)

Residuals:
    Min      1Q  Median      3Q     Max
-51.885 -23.547   0.094  20.462  49.240

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 190.9567    21.1536   9.027 3.39e-11 ***
salinity     -3.9652     0.8067  -4.915 1.55e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 28.59 on 40 degrees of freedom
Multiple R-squared:  0.3766,  Adjusted R-squared:  0.361
F-statistic: 24.16 on 1 and 40 DF,  p-value: 1.55e-05
```

Best answer: 38% of the variance in the number of copepods is explained by salinity.

Why? It rounds the reported R-squared (0.3766) to an appropriate number of significant figures. It states the two variables involved and conveys which was the independent vs. the dependent variable.

Question #7

Using the regression results above, state the equation of the line relating the number of copepods to salinity. Follow standard y=mx+b format, substituting the correct variable names for x and y, and use the values for slope and intercept.

Best answer: copepods = -3.97 * salinity + 191

Why? It reports the slope and intercept to the same precision as the data. Instead of x and y, it uses the quantities that were measured.

Question #8

You also calculated confidence limits on the slope and intercept of the linear regression of copepods and salinity. The R output is shown below. A colleague has reported a slope of -6.3 for this relationship from another ocean basin. In one sentence, state whether your results support the same relationship in your study area, adding the necessary parenthetical numerical support.

```
                2.5 %     97.5 %
(Intercept) 148.203752 233.709747
salinity     -5.595595  -2.334792
```

Best answer: The reported slope of -6.3 for copepods vs. salinity is inconsistent with our observed slope (-3.96, 95% C.I.: -5.60– -2.33).

Why? It treats what was measured — the slope of copepods vs. salinity — as the subject. As in a previous question, it frames it as whether the hypothesized/reported slope is consistent with our data, rather than the opposite, which would require a more complicated sentence structure. It includes the reported slope in the correct place, and it concludes with our results in parentheses, along with our estimate of the slope and its confidence interval.