This experiment examined the effect of three doses (dose) of vitamin C (0.5, 1, and 2 milligrams) and two supplement (supp) types (VC=as ascorbic acid and OJ=in orange juice) on the length (len) of odontoblasts (cells in tooth pulp) in guinea pigs.

Dose is being seen as a numeric variable. We need to fix that by turning it into a categorical variable (a "factor" in R-speak).

See all the means, including marginal means.
supp # these are the supp marginal means
supp
  OJ    VC
20.663 16.963

dose # these are the dose marginal means
dose
  0.5   1   2
10.605 19.735 26.100

supp:dose # these are the cell means
dose
  supp 0.5   1   2
     OJ 13.23 22.70 26.06
     VC  7.98 16.77 26.14

Now for a graph: a traditional interaction plot (commands not shown).

Finally, the ANOVA.

> aov.out = aov(len~supp*dose, data=ToothGrowth)
> summary(aov.out)  # significance stars have been erased
                   Df  Sum Sq Mean Sq F value    Pr(>F)
supp         1  205.35  205.35  15.572 0.0002312
dose         2 2426.43 1213.22  92.000 < 2.2e-16
supp:dose    2  108.32   54.16   4.107 0.0218603
Residuals   54  712.11   13.19

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Questions. Type your answers into a separate document. Acceptable formats are txt (preferred), doc, docx, and odt. Make sure your name is on that document. E-mail it to me as an attachment. You can also type your answers directly into an e-mail if you prefer, but be neat. Each question or part of a question is worth 3 points. Thus, the whole exam is 60 points. Short answers are preferred where a long answer is not necessary, and long answers are not necessary. Be concise.

1) Is this a balanced design? If so, how many subjects are there in each group?

2) How would you describe this design?

3) Examine the cell variances. (They are variances this time, not standard deviations.) Do you think there is a problem with violation of the homogeneity of variance assumption? Explain.

4) Examine the supp (supplement) marginal means and describe any effect you see there.

5) Examine the dose marginal means and describe any effect you see there.

6) Examine the cell means and describe the following effects.

   A) The simple effect of supplement at dose = 0.5. (Hint: that's column one of the cell means.)
   B) The simple effect of supplement at dose = 1.
   C) The simple effect of supplement at dose = 2.

7) Now describe the interaction effect.

8) Examine the interaction plot and tell how the following effects are shown in that graph.

   A) The main effect of supplement type.
   B) The main effect of dose.
   C) The supplement type by dose interaction.

9) Examine the ANOVA summary table and tell which of the following effects are significant. Give the p-values.

   A) The main effect of supplement type.
   B) The main effect of dose.
   C) The supplement type by dose interaction.

10) Calculate an eta-squared value for each of the following effects.

    A) The main effect of supplement type.
    B) The main effect of dose.
    C) The supplement type by dose interaction.

11) No post hoc test was done on the dose main effect, but if you wanted to do one, name three tests that could be used.

12) What is the value of the pooled variance. (Caution: pooled variance, not standard deviation.)