

## One-way MANOVA

**Good news:** You finally got a consulting job where you can put your knowledge of multivariate statistics to use.

You've been asked to consult for a company that makes dog food. They produce two kinds, with crypto-names OLD and NEW. They want to compare these with two other brands, called MAJOR and ALPS. They propose the following experiment:

- Four dogs are each separately exposed to a bowl of one of these dog foods, chosen randomly. All dogs are of the same size/weight and were last fed 12 hours before.
- For each dog, they measure the time it takes for them to start eating (START) and the amount eaten (AMOUNT).

Your job is to help them understand these data, and reach appropriate conclusions.

**Bad news:** There's no one around to help. You're on your own.

1. Read the data, `dogfood.sas` into SAS.

```
%include data(dogfood);
proc print; run;
```

2. Set up a one-way ANOVA/MANOVA to test whether there are differences among the brands on these two variables. This should get you started:

```
proc glm data=dogfood order=data;
  class ???;
  model start amount = ???;
  manova h=???; run;
```

3. In addition to the overall test of equality of all means, the company is really interested in three separate questions:
  - How do their own brands (OLD, NEW) compare with the others?
  - Is there is difference between OLD and NEW?
  - Is there a difference between MAJOR and ALPS?

Set up contrast statements to test these hypotheses. Note that the coefficients for the contrasts (with `order=data`) refer to the brands listed in their *order in the data set*.

Fill in appropriate numbers in the blanks in the contrast statement below to test these hypotheses.

```
proc glm data=dogfood order=data;
  class ???;
  model start amount = ???;
  /*
  contrast 'Ours vs. theirs' formula Old New Maj Alps */
  contrast 'Old - New      ' formula ___ ___ ___ ___ ;
  contrast 'Major - Alps   ' formula ___ ___ ___ ___ ;
```

## OneWayMANOVA

```
manova h=???; run;
```

4. What are your conclusions, taking into account both the univariate tests and the multivariate tests?

Hypothesis	MANOVA test	ANOVA: start	ANOVA: amount
Equal means			
Ours vs. theirs			
Old – New			
Major - Alps			

5. What kind(s) of plots can you make to help to show the nature of the data and illuminate these conclusions? You might want to use the `%webhelp()` facility.

```
%webhelp(boxplot);  
%webhelp(meanplot);  
%webhelp(ellipses);  
%webhelp(heplots);
```

## MANOVA in R

Without much comment, here is some code to run roughly comparable analyses in R. Note that the formula factor has been ordered alphabetically, so the contrasts refer to the levels in this order. This script is available as **N:\psy6140\tutorials\dogfood.R**. The data is also available at <http://euclid.psych.yorku.ca/www/lab/psy6140/R/dogfood.csv>.

```
dogfood <- read.csv("n:/psy6140/data/dogfood.csv")  
head(dogfood)  
  
# set up special contrasts for formula  
contrasts(dogfood$formula) <- matrix(  
  c(-1, -1, 1, 1,  
    0, 0, -1, 1,  
    -1, 1, 0, 0), nrow=4, ncol=3)  
contrasts(dogfood$formula)  
  
dog.mod <- lm(cbind(start, amount) ~ formula, data=dogfood)  
dog.mod  
library(car)  
Anova(dog.mod)  
summary(Anova(dog.mod))
```

## OneWayMANOVA

```
# test contrasts
linearHypothesis(dog.mod, "formula1", title="Ours vs. Theirs")
linearHypothesis(dog.mod, "formula2", title="Old vs. New")
linearHypothesis(dog.mod, "formula3", title="Alps vs. Major")

# visualize tests
library(heplots)
heplot(dog.mod)
heplot(dog.mod, hypotheses=list(
  "Ours vs. Theirs"="formula1",
  "Old vs. New"="formula2",
  "Alps vs. Major"="formula3"))
```