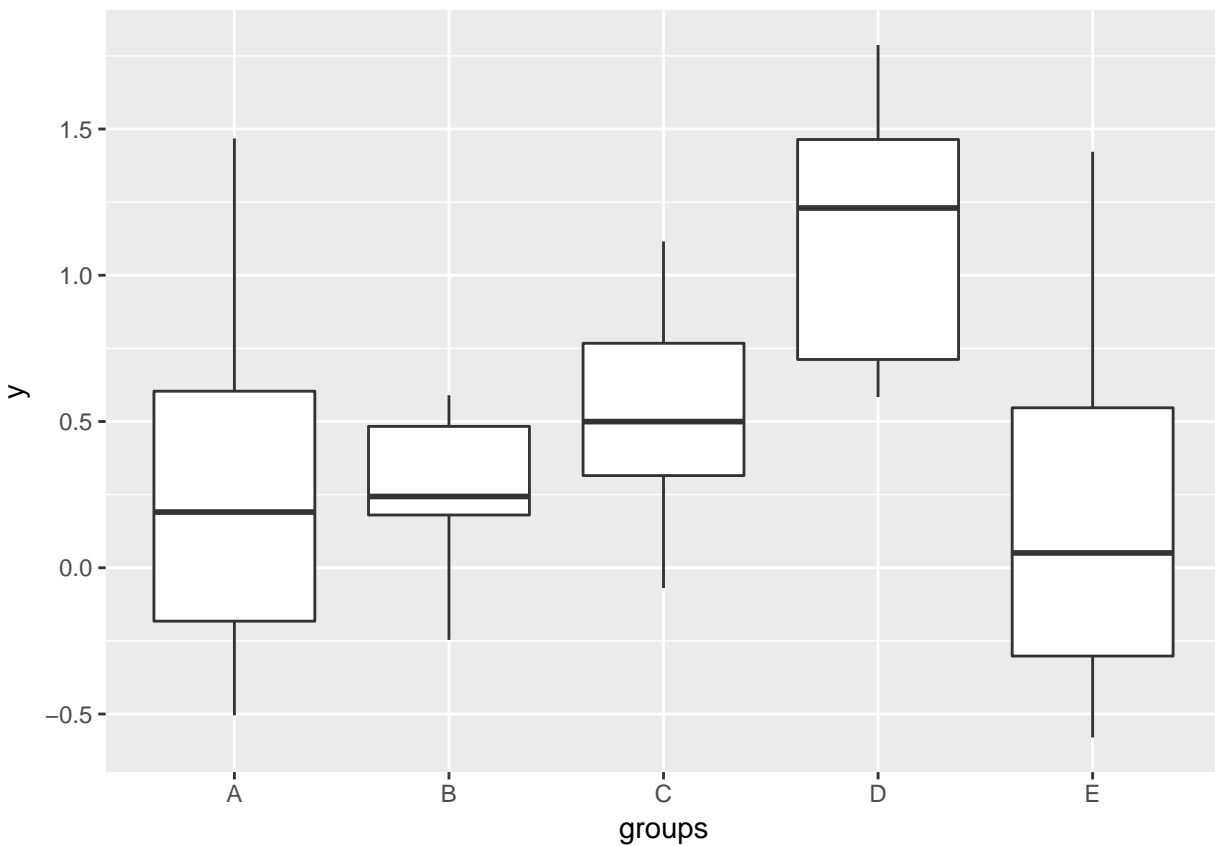# All Pairwise Comparisons

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Generate some sample data.

```
library(tidyverse)
k <- 5
n <- 10
set.seed(1)
means <- rep(runif(k), each=n)
groups <- factor((rep(LETTERS[1:k], each=n)))
all_p_data <- data_frame(groups, y=means + rnorm(k*n, 0, 0.5))
```

Plot the data.

```
all_p_data %>%
  ggplot(aes(x=groups, y=y)) + geom_boxplot()
```


Perform the ANOVA.

```
alpha <- 0.05
library(xtable)
## ANOVA results
all_p_data_fit <- all_p_data %>%
```

```
  aov(y ~ groups, data=.)

library(broom)
root_mse <- glance(all_p_data_fit)$sigma

all_p_data_fit %>% summary() %>%
  xtable(., digits=3) %>% print.xtable(., comment=FALSE)
```

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
groups	4.000	6.197	1.549	6.772	0.000
Residuals	45.000	10.295	0.229		

```
## Summary table
all_p_data %>%
  group_by(groups) %>%
  summarize(n=n(), means = mean(y)) %>%
  arrange(means) %>%
  xtable(., digits=3) %>% print.xtable(., include.rownames=FALSE, comment=FALSE)
```

groups	n	means
E	10	0.175
B	10	0.264
A	10	0.272
C	10	0.533
D	10	1.139

There are 10 groups, so there could be 45 pairwise comparisons. To control for an experimentwise error rate of 0.05, the Bonferroni correction means we need to compute the margin of error of a 99.8888889 % confidence interval:

$$D = t_{N-k,0.0022222} \cdot \sqrt{MSE}\sqrt{1/10 + 1/10} = 0.6407476$$

A pair of groups are significantly different if the means are more than D apart.

An efficient way to do all pairwise comparisons is to order the group means from smallest to largest:

```
all_p_means <- all_p_data %>%
  group_by(groups) %>%
  summarize(n=n(), means = mean(y)) %>%
  arrange(means)

all_p_means %>%
  xtable(., digits=3) %>% print.xtable(., include.rownames=FALSE, comment=FALSE)
```

groups	n	means
E	10	0.175
B	10	0.264
A	10	0.272
C	10	0.533
D	10	1.139

Write the group names in the same order. Starting with the smallest, draw a line under the group names until there is a significant difference:

$$\underline{E \quad B \quad A \quad C} \quad D$$

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Then, go back to the second smallest and do the same. Repeat until there are no more comparisons to make. In this case here is the final result:

$$\underline{E \quad B \quad A \quad \underline{C} \quad D}$$