#Paired t-test prototype
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#A paired t-test compares two sets of measurements,
#which are exactly matched for each individual of a population

**Hypotheses**:
$H_0$: mean(x1) = mean(x2)
$H_1$: mean(x1) ≠ mean(x2)

#Read in data: I'm using "iris," a data set built into r.
iris

#The following test will compare Sepal.Length between "versicolor" and "virginica"
#Assign subsets of two equal-length vectors

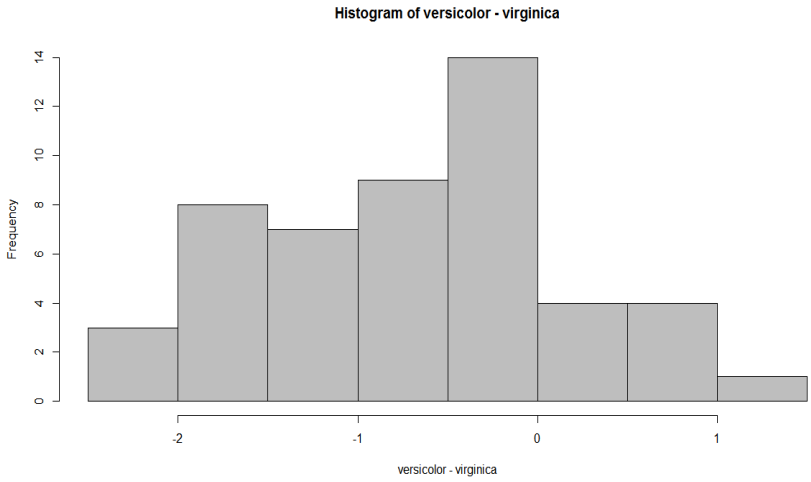
versicolor <- iris$Sepal.Length[iris$Species == "versicolor"]
virginica <- iris$Sepal.Length[iris$Species == "virginica"]

#A paired t-test is a parametric test. Must check the assumptions:

**Assumptions**:
#Observed values X1,1, X1,2, X1,3, ... X1,n are a random sample exactly matched with
#Observed values X2,1, X2,2, X2,3, ... X2,n across individuals 1,2,3, ... ,n.
#Let di= X2,i -X1,i for each individual i are a random sample from ~N(mu,Sigma).
#Variance of the population is unknown.
#Note: paired t-test is reasonably robust for deviations from normal distribution.

#verify that data vectors are the same length
length(versicolor)
**[1] 50**
length(virginica)
**[1] 50**

#Visual confirmation that differences between pairs are normally distributed
hist(versicolor - virginica, col="grey")




#Below are the manual calculations for paired t-test

#Assign vectors versicolor and virginica to variables "x1" and "x2" respectively.
x1 <- versicolor
x2 <- virginica

#assign variable "n" to sample size
n <- length(versicolor)

#assign mean and standard deviation variables
x1bar <- mean(versicolor)
x2bar <- mean(virginica)
s1 <- sd(versicolor)
s2 <- sd(virginica)

#dbar is the mean difference between paired datum
d <- x1-x2
dbar <- mean(d)
s_d <- sqrt(var(d))

#Manual calculatation of test statistic, "t"
t <- dbar/(s_d/sqrt(n))
t
**[1] -5.275345**

#Probability (P) value (two sided case)
degf <- n-1
P <- 2 * pt(t, degf)
P
**[1] 2.989652e-06**

#Confidence intervals

```
alpha <- 0.05

#T distribution
c1 <- qt(alpha/2,degf)
c1 <- -c1

#Confidence Intervals
ci_l <- dbar-c1*(s_d/sqrt(n))
ci_u <- dbar+c1*(s_d/sqrt(n))

CI <- c(ci_l, ci_u)
CI
```
**[1] -0.900371 -0.403629**

```
#Run the test using the built in function
t.test(versicolor,virginica,paired=TRUE, conf.level=0.95)
```

Output:
Paired t-test

**data: versicolor and virginica**
**t = -5.2753, df = 49, p-value = 2.99e-06**
**alternative hypothesis: true difference in means is not equal to 0**
**95 percent confidence interval:**
**-0.900371 -0.403629**
**sample estimates:**
**mean of the differences**
**-0.652**