ModellingTandF.R

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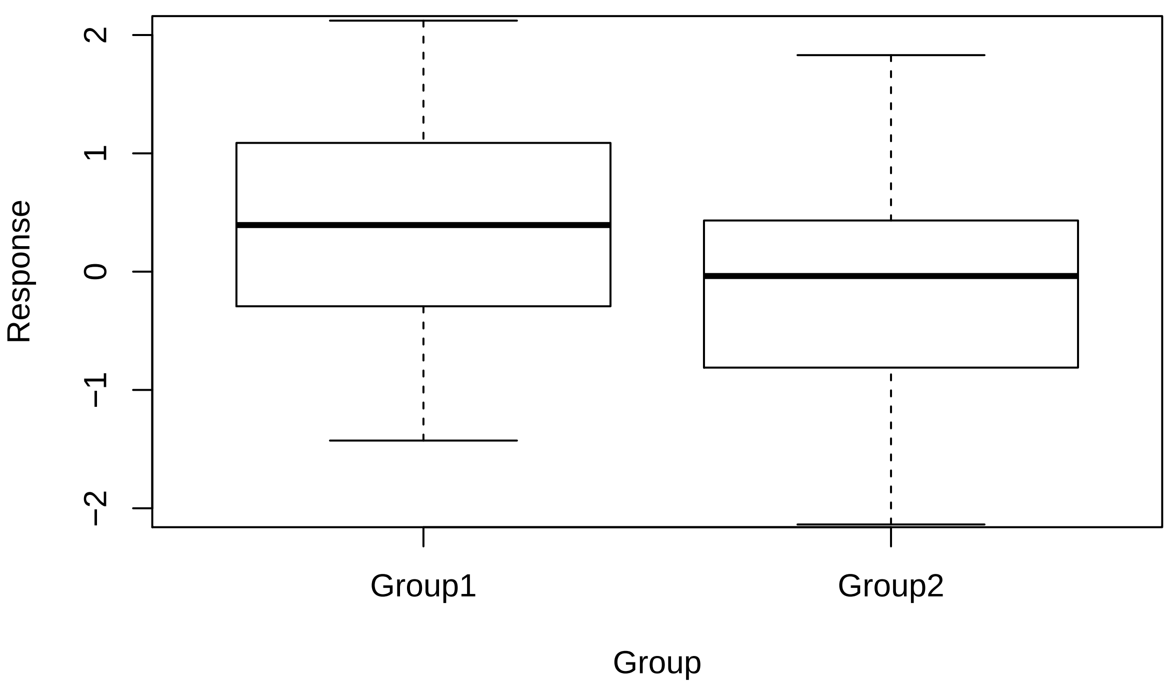
```r
# Use this script to demonstrate how to Knit output to share code and results with colleagues
# and to demonstrate the use of functions, randomised sampling, and empirically
# demonstrating how to arrive at the T and F distributions.  Hopefully, this might
# demystify obscure statistics.

# Call Libraries
library(ggplot2)

# Random data can easily be generated in R
# Create two data sets, x and y that are both 30 samples, drawn from a normal distribution,
# mean = 0 and sd = 1
set.seed(14) # try 14
n=30
x<-rnorm(n=30, mean=0, sd=1)
y<-rnorm(n, 0, 1)
z<-data.frame(Group=factor(c(rep("Group1", n), rep("Group2", n))), Response=c(x,y))
plot(Response ~ Group, z, ylim=c(-2,2))
```

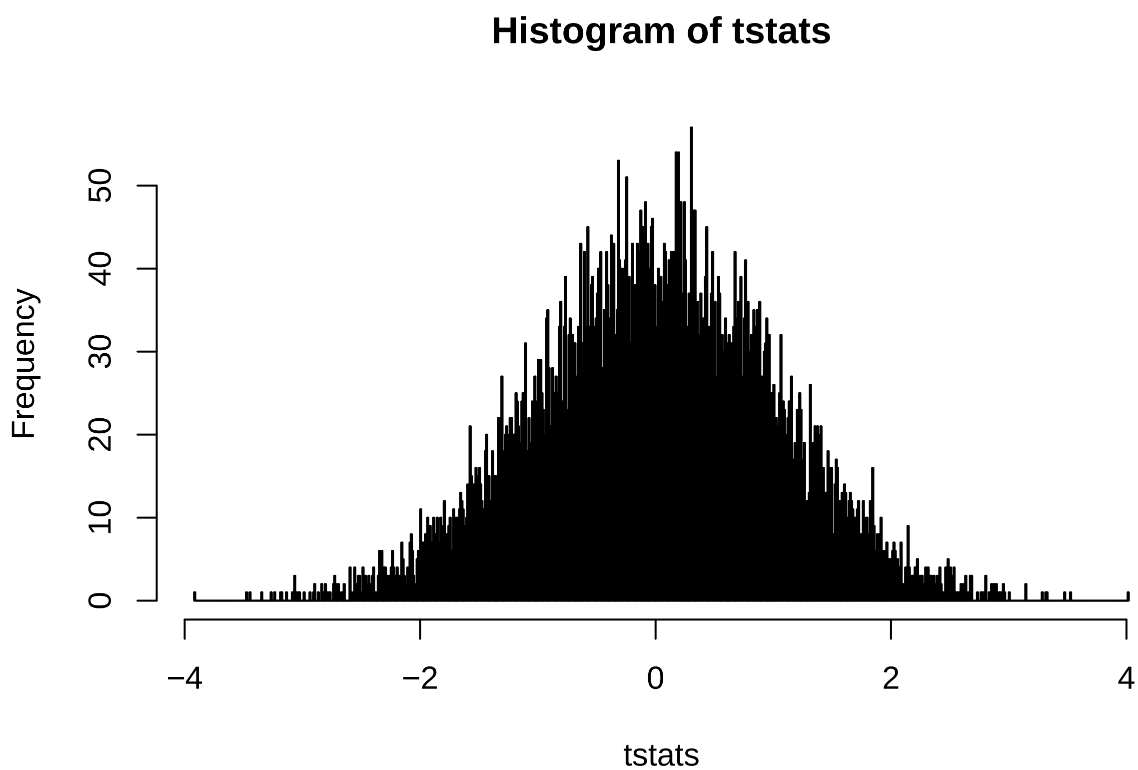



```r
t.test(Response ~ Group, data=z, var.equal=T)
```

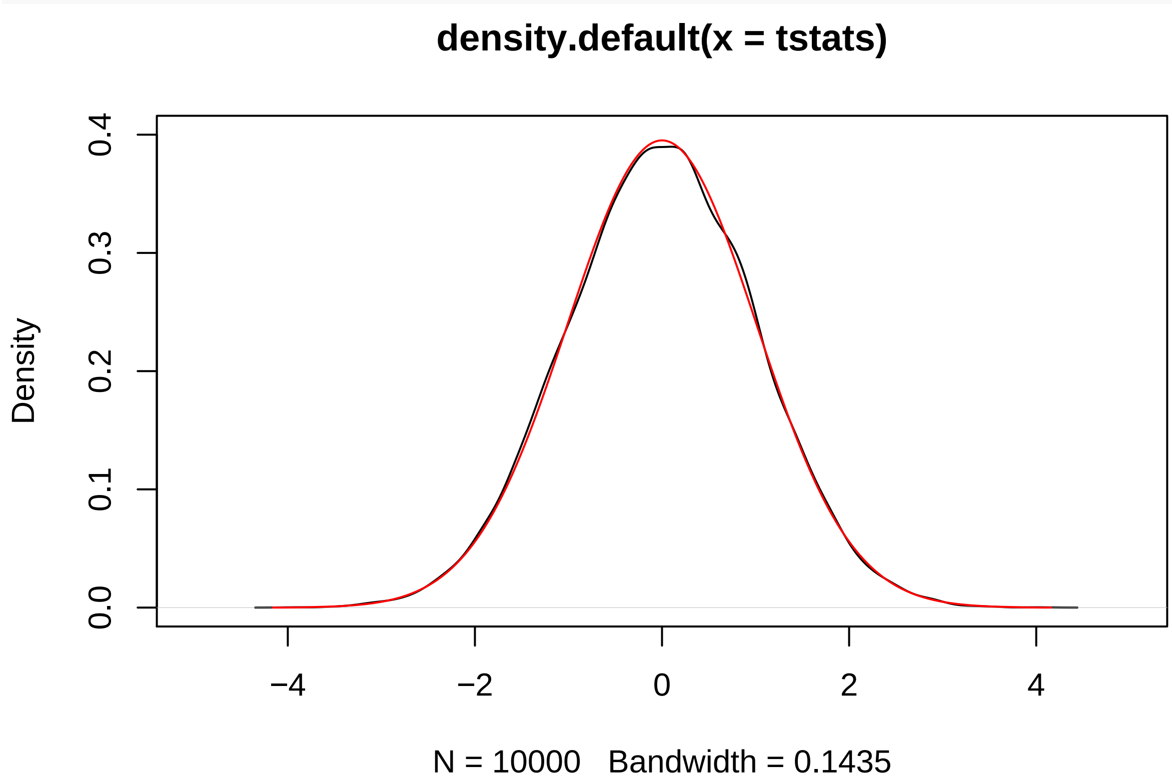
```
##
##  Two Sample t-test
##
## data:  Response by Group
## t = 2.4084, df = 58, p-value = 0.01922
## alternative hypothesis: true difference in means is not equal to 0
```

```
## 95 percent confidence interval:
##  0.09754805 1.05781299
## sample estimates:
## mean in group Group1 mean in group Group2
##            0.4235508           -0.1541297
```

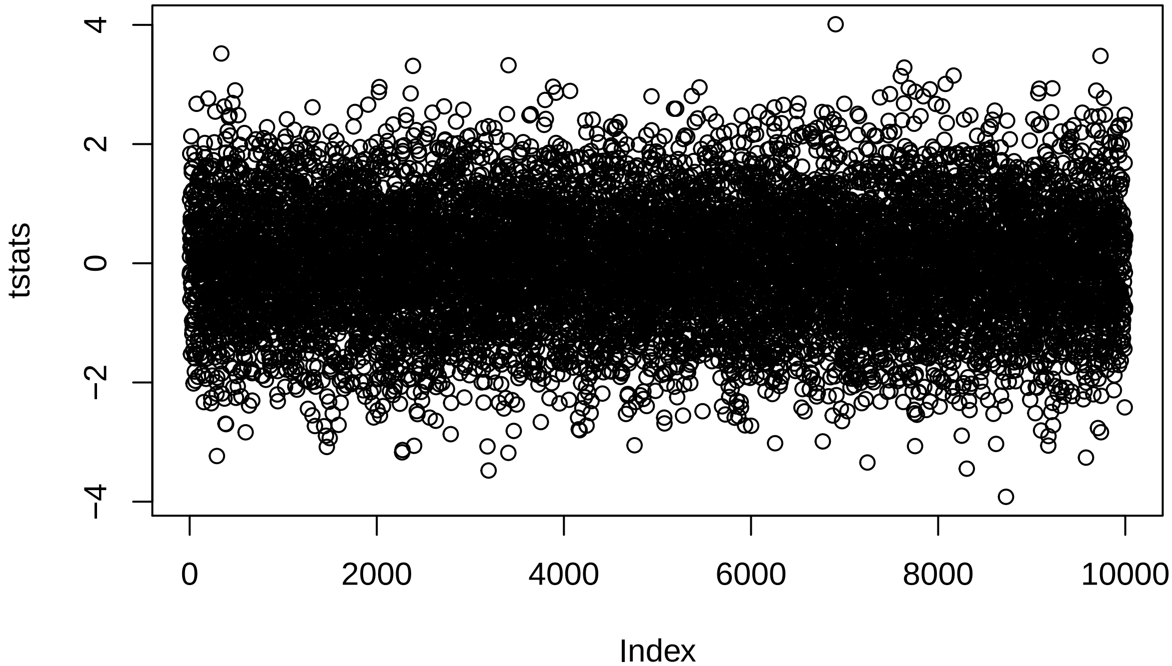
```r
# Interesting result, we conclude that these are possibly significantly
# different from one another?!

# Usually we run our stats without knowing much about the theory.  A t statistic is
# compared against a theoretical
# distribution that is a formula, see here for these formulae:
# https://support.minitab.com/en-us/minitab-express/1/help-and-how-to/basic-statistics/probability-dist

# But if we can generate random data, we should be able to generate an
# empirical set of data that exhibits the
# distribution resulting from these formulae.

# Let's do this by using the replicate function, which performs a function
# we define, runs it as many times as you
# ask, and then collects the result.  We'll replicate our tcalc() function
# 10,000 times.

# First define function to return the t statistic from a two sample t test
# for randomly generated datasets of size n,
# derived from normally distributed data
tcalc<-function(n=10){
  x<-rnorm(n, 0,1)
  y<-rnorm(n, 0,1)
  z<-data.frame(Group=factor(c(rep("Group1", n), rep("Group2", n))), Response=c(x,y))
  t<-(mean(x)-mean(y))/(sqrt((sd(x)^2)/n+(sd(y)^2)/n))
  # t<-t.test(Response ~ Group, data=z, var.equal=T)$statistic
  return(t)
}

tstats<-replicate(10000, tcalc(n=1000))
hist(tstats, breaks=1000)
```



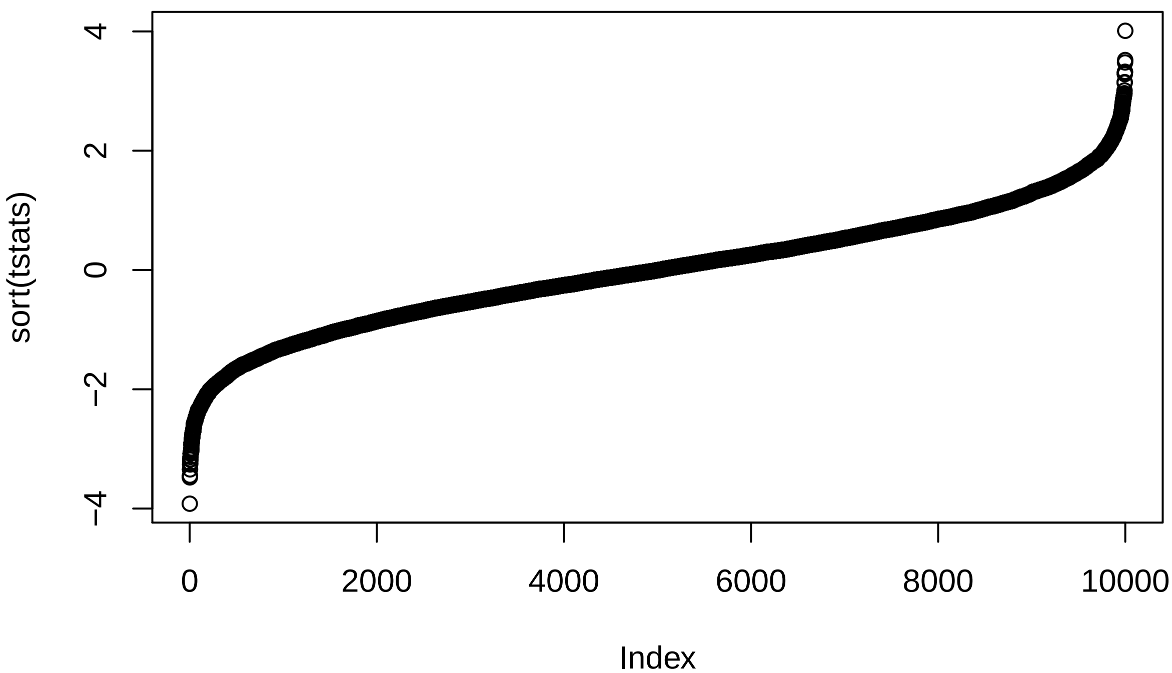

```
# Hmm....looks like t distribution data that also has noise attached to it.
# Let's make use of the density function, which
plot(density(tstats), xlim=c(-5,5), ylim=c(0,0.4))
p<-seq(0, 1, 0.0001)
lines(density(qt(p, df=998)), xlim=c(-5,5),  ylim=c(0,0.4), col="red")
```



```r
# our empirical distribution overlaps with that determined from the t density formula

plot(tstats)
```




```r
plot(sort(tstats))
```




```r
# out of 10000 randomly generated statistics, if you sort them, you can pull out
# the ith percentile out of the 10000 available n
sort(tstats)[9750] # 97.5th percentile from the bootstrapped tstats
```

```
## [1] 1.941606
```

```r
# Or use the empirical cumulative distribution function to tell you what percentile
# a given value would yield if it was derived from your sample distribution
ecdf(tstats)(1.96)
```

```
## [1] 0.9758
```

```r
# Compare these to using the built-in, calculated t distribution functions:
qt(0.975, df=58)
```

```
## [1] 2.001717
```

```r
qt(0.975, df=100)
```

```
## [1] 1.983972
```

```r
qt(0.975, df=10000)
```

```
## [1] 1.960201
```

```r
# 1.96 should ring a bell as the t stat used when estimating 95% confident limits,
# assuming large sample sizes where t distributions resemble normal distributions:
qnorm(0.975)
```

```
## [1] 1.959964
```

```r
t.test(Response ~ Group, data=z, var.equal=T)$statistic
```

```
##        t
## 2.408404
```

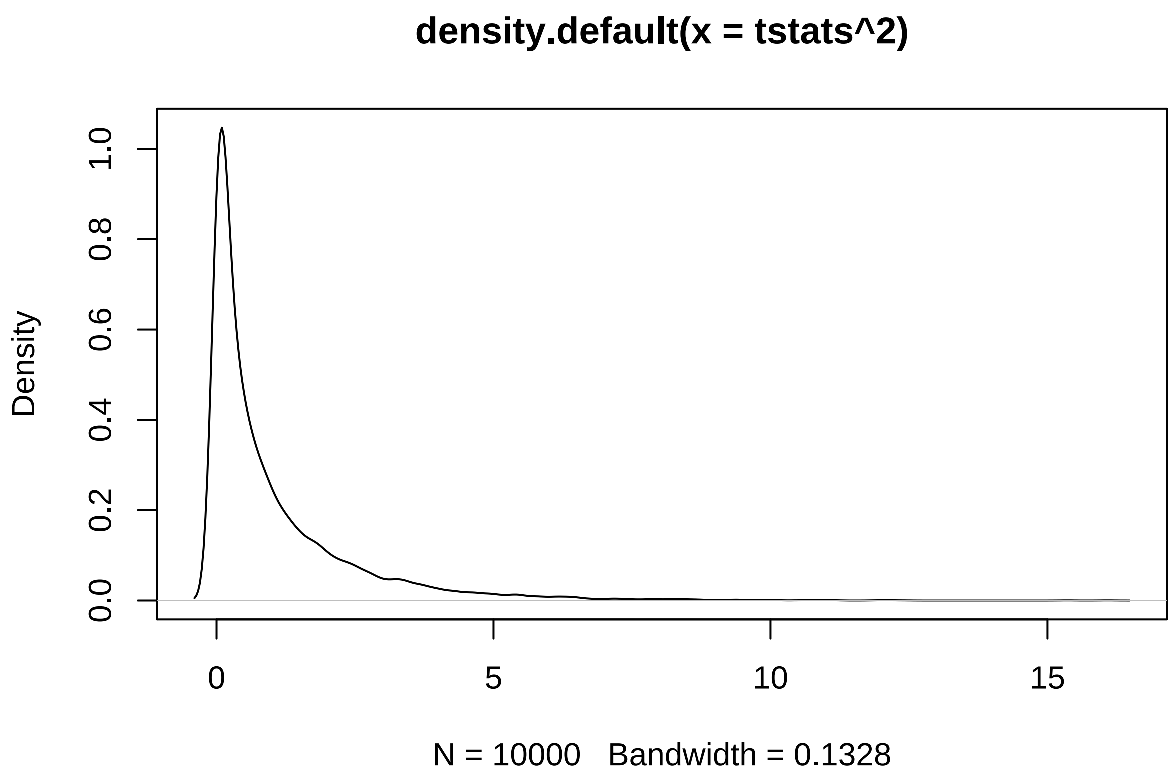
```r
anova(lm(Response ~ Group, data=z))
```

```
## Analysis of Variance Table
##
## Response: Response
##           Df Sum Sq Mean Sq F value  Pr(>F)
## Group      1  5.006  5.0057  5.8004 0.01922 *
## Residuals 58 50.054  0.8630
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

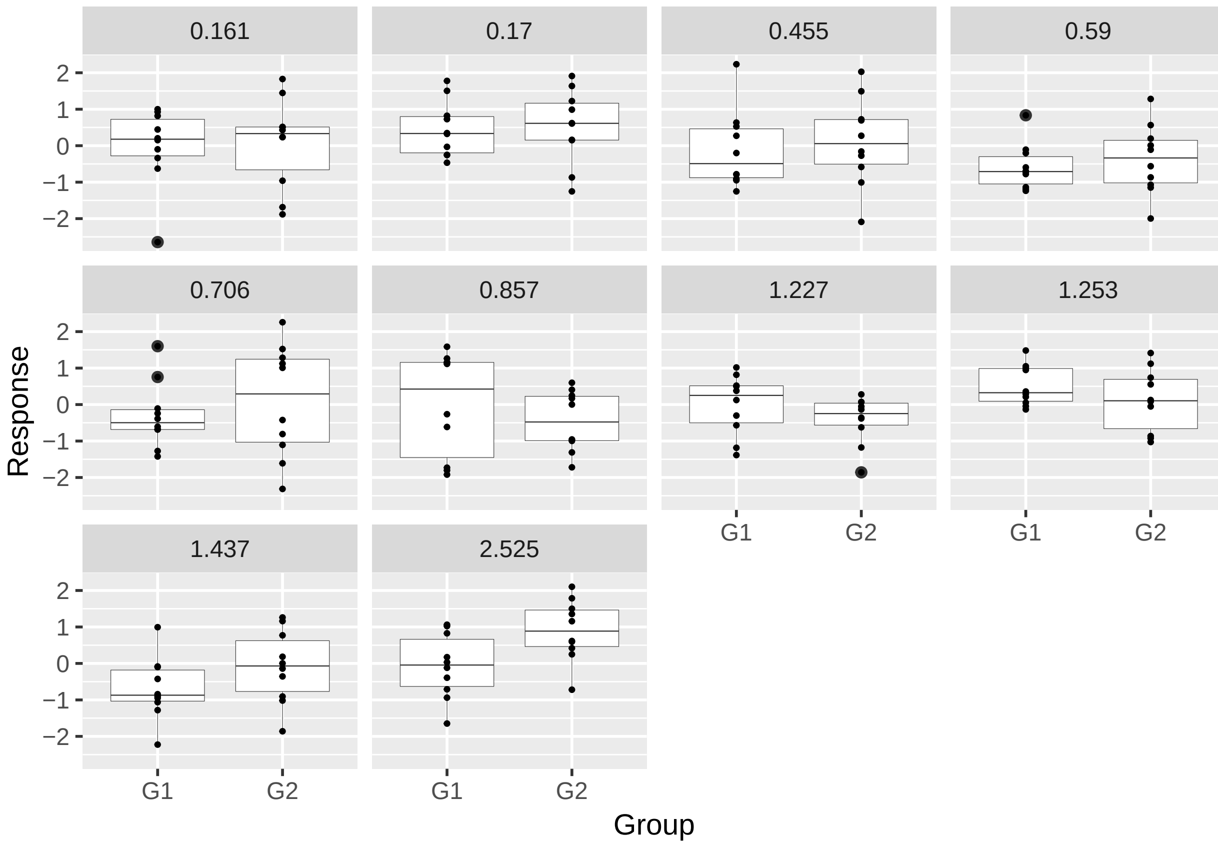
```r
t.test(Response ~ Group, data=z, var.equal=T)$statistic^2
```

```
##        t
## 5.800412
```

```r
# note: square of the t-statistic = the F statistic from the one way anova, just as
# squaring the tstat distribution should resemble the fstat distribution

# T distribution squared
plot(density(tstats^2))
```



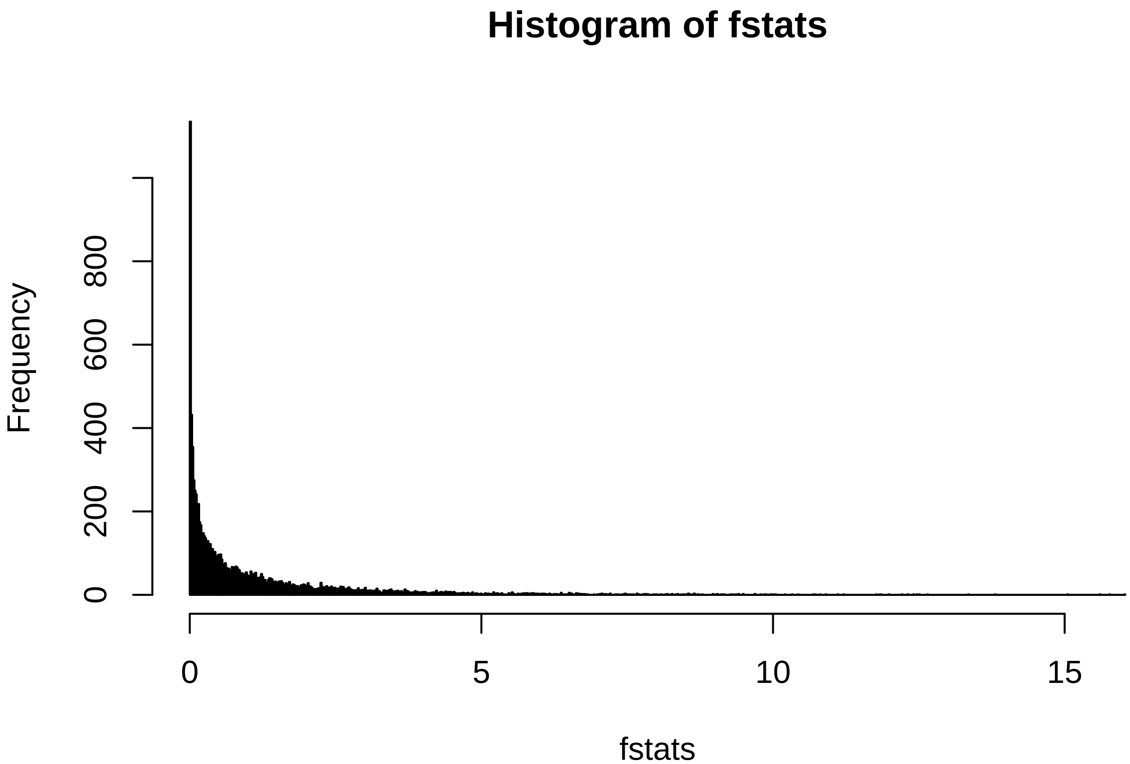

```
zz<-data.frame()
for(r in 1:10){
  n=10
  x<-rnorm(n, 0,1)
  y<-rnorm(n, 0,1)
  z<-data.frame(Replicate=r,
                Group=factor(c(rep("G1", n), rep("G2", n))),
                Response=c(x,y),
                Tstat=abs((mean(x)-mean(y))/(sqrt((sd(x)^2)/n+(sd(y)^2)/n))))
  zz<-rbind(zz,z)
}
zz$Tstat<-factor(round(zz$Tstat, 3))

# A random sample of 10 randomly created data sets, assuming 2 groups were drawn from
# the same distribution at random
ggplot(zz, aes(x=Group, y=Response))+
  facet_wrap(~Tstat)+
  geom_boxplot(size=0.1)+
  geom_point(size=0.5)
```



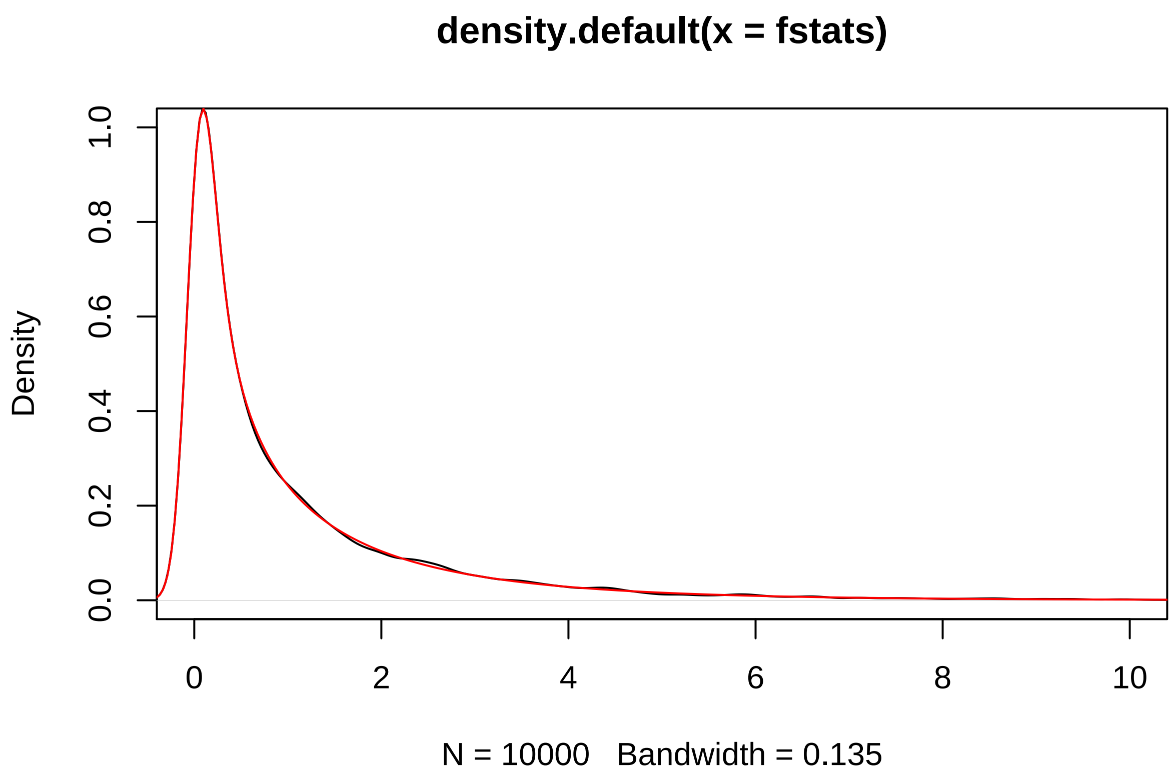

```
# Define Function to return the F statistic for randomly generated data (One Way ANOVA)
fcalc<-function(n1=2, n2=20){
      x<-rnorm(n1, 0, 1)
      y<-rnorm(n2, 0, 1)
      z<-data.frame(Group=factor(c(rep("Group1", n1), rep("Group2", n2))), Response=c(x,y))
      f<-data.frame(anova(lm(Response ~ Group, z)))[1,4]
      return(f)
    }

# Look at F distribution:
n1=20
n2=20
x<-rnorm(n1, 0, 1)
y<-rnorm(n2, 0, 1)
z<-data.frame(Group=factor(c(rep("Group1", n1), rep("Group2", n2))), Response=c(x,y))
anova(lm(Response ~ Group, z))
```

```
## Analysis of Variance Table
##
## Response: Response
##           Df Sum Sq Mean Sq F value  Pr(>F)
## Group      1  3.577  3.5770  3.5974 0.06549 .
## Residuals 38 37.785  0.9943
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
# Replicate two groups that you want to perform an ANOVA on.
# If n1=20 and n2=20, the degrees of freedom from a one-way ANOVA will be:
# Numerator df = 1
# Denominator df = 38
fstats<-replicate(10000, fcalc(n1=20, n2=20))
hist(fstats, breaks=1000)
```




```r
plot(density(fstats), xlim=c(0,10), ylim=c(0,1))
lines(density(qf(seq(0, 1, 0.0001), df1=1, df2=38, lower.tail = T)),
      xlim=c(0,10), ylim=c(0,1), col="red")
```



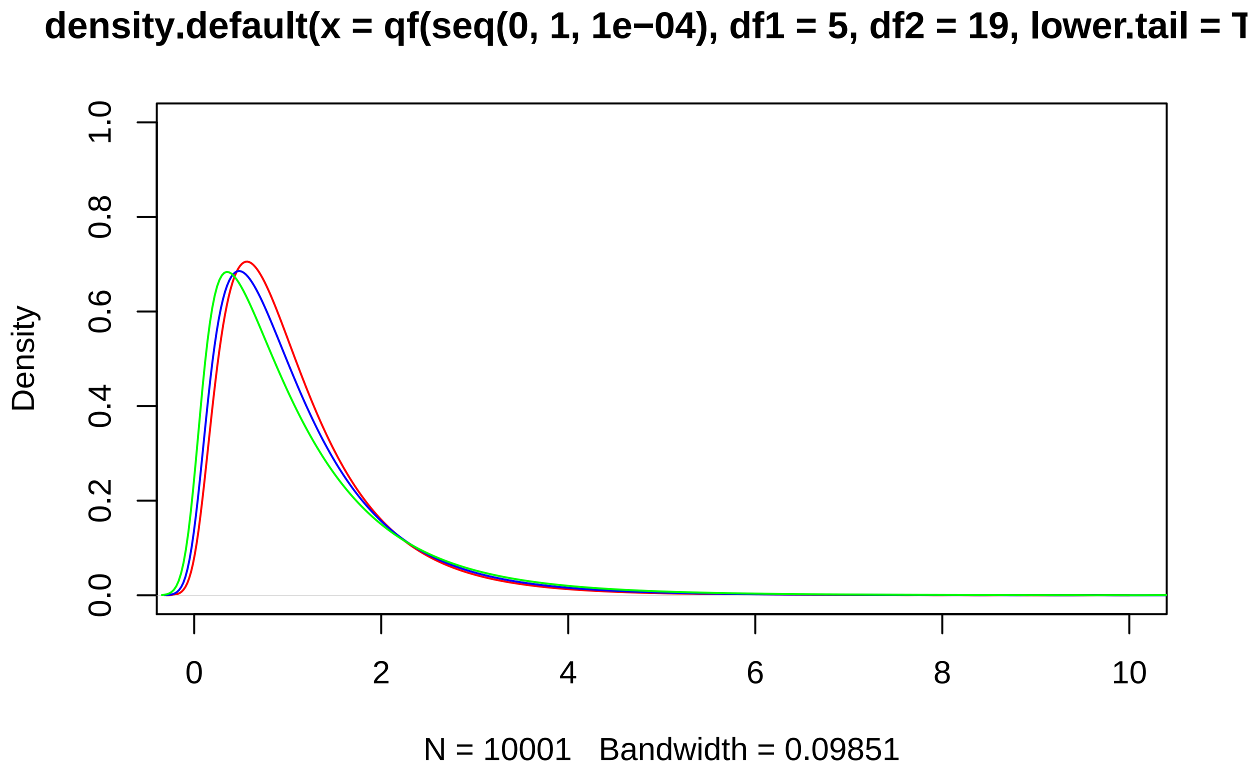

```
sort(fstats)[9500] # 95% percentile from the fstats replicated values
```

```
## [1] 4.100785
```

```
qf(0.95, df1=1, df2=38) # 95th percentile calculated using the built in function
```

```
## [1] 4.098172
```

```
plot(density(qf(seq(0, 1, 0.0001), df1=5, df2=19, lower.tail = T)),
      xlim=c(0,10), ylim=c(0,1), col="red")
lines(density(qf(seq(0, 1, 0.0001), df1=4, df2=19, lower.tail = T)),
      xlim=c(0,10), ylim=c(0,1), col="blue")
lines(density(qf(seq(0, 1, 0.0001), df1=3, df2=19, lower.tail = T)),
      xlim=c(0,10), ylim=c(0,1), col="green")
```


density.default(x = qf(seq(0, 1, 1e−04), df1 = 5, df2 = 19, lower.tail = T
Density
0.0
0.2
0.4
0.6
0.8
1.0
0
2
4
6
8
10
N = 10001   Bandwidth = 0.09851