HW5

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August 8, 2019

IST777 Homework 5 - Professor Stanton

```r
#============================================================================
#==> Homework 5; ist777; Prof. Stanton; 5, Q:6-10, pg 86 ===========
#==> Brian Hogan, aka BBE
#============================================================================
#==> HW-5 by Brian Hogan: produced the material below referencing material
#     in "Reasoning with Data" by Prof. Stanton.
# JAGS install help from Professor Miyamoto from University of Washington
#============================================================================
options(warn= (-1) ) #turn off viewing
library(MCMCvis); library(rjags); library(BEST); library(effsize)
```

```
## Loading required package: coda

## Linked to JAGS 4.3.0

## Loaded modules: basemod,bugs

## Loading required package: HDInterval
```

```r
#exercise 6:
table(PlantGrowth$group) #sample size
```

```
##
## ctrl trt1 trt2
##   10   10   10
```

```r
tapply(PlantGrowth$weight,PlantGrowth$group,mean) #mean each group
```

```
##  ctrl  trt1  trt2
## 5.032 4.661 5.526
```

```r
t.test(PlantGrowth$weight[PlantGrowth$group=="ctrl"],
       PlantGrowth$weight[PlantGrowth$group=="trt1"] ) #t.test mean compare
```

```
##
##  Welch Two Sample t-test
##
## data:  PlantGrowth$weight[PlantGrowth$group == "ctrl"] and PlantGrowth$weight[PlantGrowth$group == "t
## t = 1.1913, df = 16.524, p-value = 0.2504
## alternative hypothesis: true difference in means is not equal to 0
```

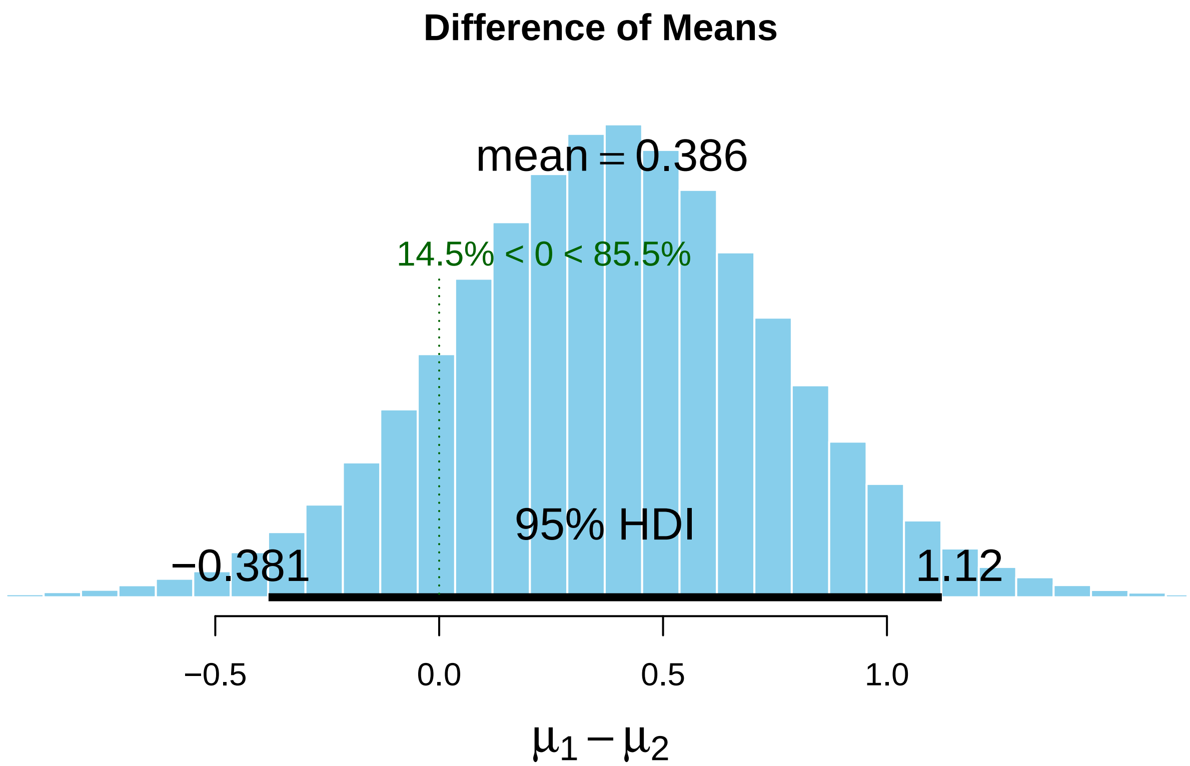
```
## 95 percent confidence interval:
##  -0.2875162  1.0295162
## sample estimates:
## mean of x mean of y
##     5.032     4.661
```

```
#=> Analyzed plant growth treatments options for 2 groups and a control group
#   each with n=10. For treatment group 1 and the control group the observed
#   t-value was 1.1913, with 16.525 degrees of freedom, a p-value of 0.2504
#   and a 95% confidence interval of -0.2876 to 1.0296. Based on an alpha of
#   0.05 we fail to reject the null hypothesis as there is no evidence of a
#   mean difference between the control and treatment-1 groups.

#Exercise 7:
#==> installing BEST, JAGS, and rjags was  challenging but the following notes
# from Professor Miyamoto from University of Washington made this possible.
# https://faculty.washington.edu/jmiyamot/p548/installing.jags.pdf
#--------------------------------------------------------------------------
# The high density interval (HDI) boundaries are -0.37 and 1.14 so there is a
# 95% probabiliyt the population mean difference between the control and
# treatment-1 groups is in this range. The greatest likelihood for a
# population mean difference is near 0.385 roughly between the region of
# 0 to 1.
# The expression: 14.5% < 0 < 85.5% means 14.5% of mean differences run in
# MCMC were negative while 85.5% were positive. This implies the chances the
# control group were equal to or better than the treatment group "are not"
# close to zero, rather 85.5% of the population means are different.
plantbest <-BESTmcmc(PlantGrowth$weight[PlantGrowth$group=="ctrl"],
                     PlantGrowth$weight[PlantGrowth$group=="trt1"] )
```

```
## Waiting for parallel processing to complete...
```

```
## done.
```

```
plot(plantbest)  #plotAll(plantbest)
```




```r
#Exercise 8:
t.test(PlantGrowth$weight[PlantGrowth$group=="ctrl"],
       PlantGrowth$weight[PlantGrowth$group=="trt1"] )
```

```
##
##  Welch Two Sample t-test
##
## data:  PlantGrowth$weight[PlantGrowth$group == "ctrl"] and PlantGrowth$weight[PlantGrowth$group == "t
## t = 1.1913, df = 16.524, p-value = 0.2504
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.2875162  1.0295162
## sample estimates:
## mean of x mean of y
##     5.032     4.661
```

```r
plantbest
```

```
## MCMC fit results for BEST analysis:
## 100002 simulations saved.
##           mean      sd  median  HDIlo  HDIup  Rhat n.eff
## mu1      5.0260  0.2254  5.0256 4.5837  5.481 1.000 54098
## mu2      4.6399  0.3059  4.6373 4.0373  5.256 1.000 55782
## nu      34.2775 29.6572 25.5519 1.2279 94.111 1.000 20793
## sigma1   0.6603  0.2025  0.6226 0.3347  1.057 1.001 26994
```

```
## sigma2  0.8949  0.2781  0.8435 0.4558  1.445 1.000 25231
##
## 'HDIlo' and 'HDIup' are the limits of a 95% HDI credible interval.
## 'Rhat' is the potential scale reduction factor (at convergence, Rhat=1).
## 'n.eff' is a crude measure of effective sample size.
```

```
# The t-test 95% CI of -0.287 and 1.029 indicate a small window, ie 1.32, or
# narrow interval estimate3 of the population value. However, at a p-value
# of 0.05 we would NOT reject the null hypothesis the means are different
# indicating there is no evidence treatment group 1 is doing better than
# the control group. The BESTmcmc informs that 85.5% of the means generated
# are greater than zero providing evidence of 100,002 samples that the
# the treatment group population mean is not illustrating enough evidence
# of a mean growth difference from the the control group. There are only
# ten samples and plotAll(plantbest) [below] for the Group 2 Std. Dev.
# does illustrate some skewness to the right so the t-dist may not be
# performing as well as it could as the data is a little skewed right.
# However, all evidence indicates a lack of evidence of a difference in
# plant growth for treatment 1 compared to the control group.

#Exercise 9:
t.test(PlantGrowth$weight[PlantGrowth$group=="ctrl"],
       PlantGrowth$weight[PlantGrowth$group=="trt2"] )
```

```
##
##  Welch Two Sample t-test
##
## data:  PlantGrowth$weight[PlantGrowth$group == "ctrl"] and PlantGrowth$weight[PlantGrowth$group == "
## t = -2.134, df = 16.786, p-value = 0.0479
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.98287213 -0.00512787
## sample estimates:
## mean of x mean of y
##     5.032     5.526
```

```
#5.032-5.526 = 0.494 t-=test mean difference
# -0.98287-(-0.005127) =0.98   #confidence internval difference t-test
cohen.d(PlantGrowth$weight[PlantGrowth$group=="ctrl"],
        PlantGrowth$weight[PlantGrowth$group=="trt2"] )
```

```
##
## Cohen's d
##
## d estimate: -0.954363 (large)
## 95 percent confidence interval:
##       lower       upper
## -1.94596749  0.03724157
```

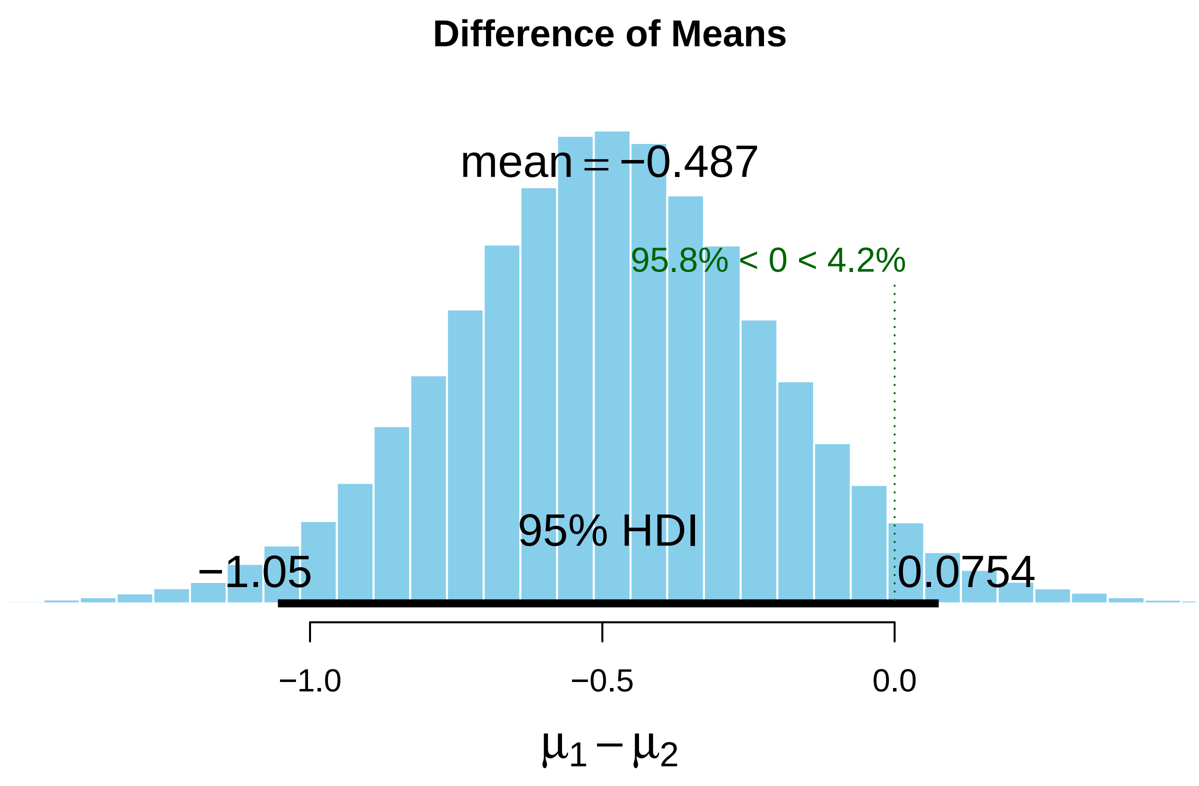
```
plantbest2 <-BESTmcmc(PlantGrowth$weight[PlantGrowth$group=="ctrl"],
                      PlantGrowth$weight[PlantGrowth$group=="trt2"] )
```

```
## Waiting for parallel processing to complete...done.
```

```r
plantbest2
```

```
## MCMC fit results for BEST analysis:
## 100002 simulations saved.
##           mean      sd  median  HDIlo   HDIup  Rhat n.eff
## mu1      5.0274  0.2283  5.0269 4.5800  5.4836 1.000 52944
## mu2      5.5148  0.1730  5.5132 5.1749  5.8625 1.000 57008
## nu      34.3069 29.5018 25.6977 1.1364 92.7641 1.001 20724
## sigma1   0.6611  0.2055  0.6232 0.3416  1.0628 1.002 24255
## sigma2   0.5032  0.1598  0.4728 0.2551  0.8201 1.002 23783
##
## 'HDIlo' and 'HDIup' are the limits of a 95% HDI credible interval.
## 'Rhat' is the potential scale reduction factor (at convergence, Rhat=1).
## 'n.eff' is a crude measure of effective sample size.
```

```r
plot(plantbest2)
```




```r
# At a significant level of 0.05 the t-test p-value of 0.048 informs there
# a mean difference between the plant growth control group and treatment
# group 2. The span of -0.983 up to -0.005 is the weight of evidence the
# population difference in plant growth is a negative number somewhere
# between the region of -0.494 plant growth plus or minus half the CI
# of 0.98 or ~0.49. Bayesian evidence generates an HDI between -1.05 and
# 0.0718 with a mean of -0.485 providing a 95% probability the popluation
```

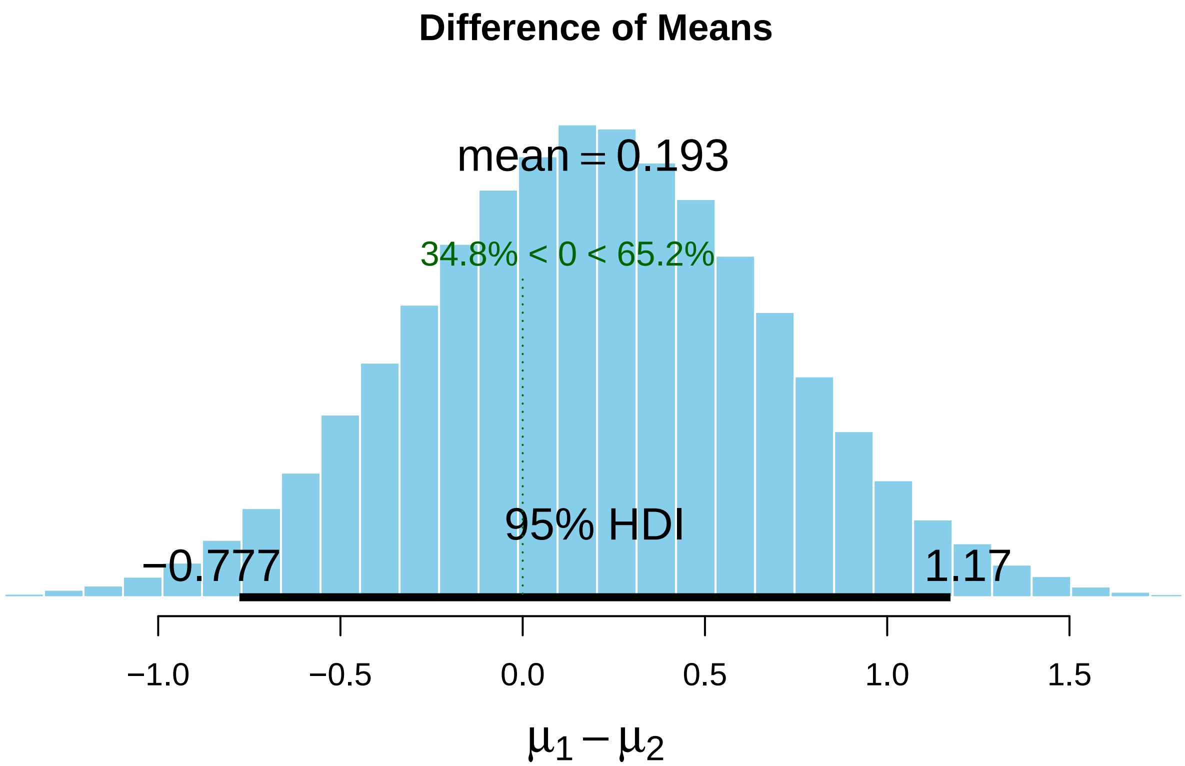
```r
# mean difference falls within this range.Overall there is substantial
# evidence to support plant growth treatment #2 has a 95% likely value
# of being ~0.49 improvement over the control group. This has directional
# agreement with the t-test point estimate of the sample's mean difference.
# The Cohen's D measure also indicates a large effect size indicating
#treatment 2 was providing almost a full standard deviation more of growth.

#Exercise 10:
t.test(rnorm(100000, mean=17.1,sd=3.8),rnorm(100000,mean=17.2,sd=3.8))
```

```
##
##  Welch Two Sample t-test
##
## data:  rnorm(1e+05, mean = 17.1, sd = 3.8) and rnorm(1e+05, mean = 17.2, sd = 3.8)
## t = -4.399, df = 2e+05, p-value = 1.088e-05
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.10834977 -0.04155861
## sample estimates:
## mean of x mean of y
##  17.10447  17.17942
```

```r
best3 <-BESTmcmc(rnorm(100, mean=17.1,sd=3.8),
                 rnorm(100,mean=17.2,sd=3.8))
```

```
## Waiting for parallel processing to complete...done.
```

```r
plot(best3)
```




```
#-0.13 -(-0.063) = -0.067 CI span
# At a p-value 0.001 we would reject the null hypothesis of a mean difference
# betweeen fuel consumption for 17.1 and 17.2. The span of evidence ranges
# from -0.13 to -0.063 or -0.067 suggesting population mean is contained
# within this range. Bayesian eveidence suggests an HDI range of -1.22 to
# 0.968 with 95% probability of the popoulation mean difference of -0.12.
# However, 58.6% of the samples are below zero suggesting more than half
# the time there is no difference in the population means between these
# two samples. As such, when performing null hypothesis significance tests
# on large samples it is important to build other methods of evidence
# before interpreting outcomes and accepting the rejection of the null
# hypothesis. In this case, the standard deviations of 3.8 were large enough
# to contribute over samples to the rejection of a mean difference with a
# 10th of a percent difference. This suggest the "region of practical
# equivalence" should be assessed to determine if out of 100,000 tests
# with a t of 1.1e-08/100000 or not even 1/10th out of a 100,000 t-tests
# would yield a value of t larger in magnitude than -5.7144. How is this
# evidence acceptable? The bottomline is from an evidence point of view
# should be careful of very large samples and p-value calculations in
# accepting or rejecting significance testing.
```

END HOMEWORK 5