The Mark of a Criminal Record Revisited

The dataset is called `exam3.csv`. You may not need to use all of these variables for this activity. We've kept these unnecessary variables in the dataset because it is common to receive a dataset with much more information than you need.

Name	Description
`jobid`	Job ID number
`callback`	`1` if tester received a callback, `0` if the tester did not receive a callback.
`black`	`1` if the tester is black, `0` if the tester is white.
`crimrec`	`1` if the tester has a criminal record, `0` if the tester does not.
`interact`	`1` if tester interacted with employer during the job application, `0` if tester doesn't interact with employer.
`city`	`1` is job is located in the city center, `0` if job is located in the suburbs.
`distance`	Job's average distance to downtown.
`custserv`	`1` if job is in the costumer service sector, `0` if it is not.
`manualskill`	`1` if job requires manual skills, `0` if it does not.

The problem will give you practice with:

- constructing confidence intervals
- difference-of-means tests
- p-values
- type I and type II errors

Question 1

Begin by loading the data into R and explore the data. How many cases are there in the data? Run `summary()` to get a sense of things. In how many cases is the tester black? In how many cases is he white?

Answer

```
callback <- read.csv("exam3.csv")

#(callback)
summary(callback)
```

```
##      jobid           callback          black          crimrec      
##  Min.   :   1.00   Min.   :0.0000   Min.   :0.000   Min.   :0.0000  
##  1st Qu.:  87.75   1st Qu.:0.0000   1st Qu.:0.000   1st Qu.:0.0000  
##  Median :1024.50   Median :0.0000   Median :1.000   Median :0.0000  
##  Mean   : 658.57   Mean   :0.1638   Mean   :0.569   Mean   :0.4986  
##  3rd Qu.:1112.25   3rd Qu.:0.0000   3rd Qu.:1.000   3rd Qu.:1.0000  
```

```
##  Max.   :1200.00   Max.   :1.0000   Max.   :1.000   Max.   :1.0000
##
##     interact          city           distance        custserv
##  Min.   :0.0000   Min.   :0.0000   Min.   : 0.00   Min.   :0.0000
##  1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.: 8.00   1st Qu.:0.0000
##  Median :0.0000   Median :0.0000   Median :12.00   Median :1.0000
##  Mean   :0.2428   Mean   :0.3919   Mean   :11.96   Mean   :0.6282
##  3rd Qu.:0.0000   3rd Qu.:1.0000   3rd Qu.:16.00   3rd Qu.:1.0000
##  Max.   :1.0000   Max.   :1.0000   Max.   :25.00   Max.   :1.0000
##                   NA's   :2        NA's   :2       NA's   :2
##   manualskill
##  Min.   :0.0000
##  1st Qu.:0.0000
##  Median :0.0000
##  Mean   :0.4813
##  3rd Qu.:1.0000
##  Max.   :1.0000
##  NA's   :2
```

```
sum_black <- sum(callback$black)
sum_white <- nrow(callback) - sum(callback$black)
```

There were 396 cases where the tester was black and 300 cases when the tester was white.

Question 2

Now we examine the central question of the study. Calculate the proportion of callbacks for white applicants with a criminal record, white applicants without a criminal record, black applicants with a criminal record, and black applicants without a criminal record.

```
white_applicants.crim <- subset(callback, subset = (black == 0 & crimrec == 1))
black_applicants.crim <- subset(callback, subset = (black == 1 & crimrec == 1))
white_applicants.norec <- subset(callback, subset = (black == 0 & crimrec == 0))
black_applicants.norec <- subset(callback, subset = (black == 1 & crimrec == 0))

prop.white.crim <- sum(white_applicants.crim$callback == 1) / nrow(white_applicants.crim)
prop.white.norec <- sum(white_applicants.norec$callback == 1) / nrow(white_applicants.norec)

prop.black.crim <- sum(black_applicants.crim$callback == 1) / nrow(black_applicants.crim)
prop.black.norec <- sum(black_applicants.norec$callback == 1) / nrow(black_applicants.norec)
```

Question 3

Now consider the callback rate for white applicants with a criminal record. Construct a 95% confidence interval around this estimate. Also, construct a 99% confidence interval around this estimate.

```
t.test(white_applicants.crim$callback)
```

```
##
##  One Sample t-test
##
```

```
## data:  white_applicants.crim$callback
## t = 5.4589, df = 149, p-value = 1.956e-07
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  0.1063371 0.2269963
## sample estimates:
## mean of x
## 0.1666667
```

```
t.test(white_applicants.crim$callback, conf.level = .99)
```

```
##
##  One Sample t-test
##
## data:  white_applicants.crim$callback
## t = 5.4589, df = 149, p-value = 1.956e-07
## alternative hypothesis: true mean is not equal to 0
## 99 percent confidence interval:
##  0.0870044 0.2463289
## sample estimates:
## mean of x
## 0.1666667
```

By using the t.test we see that the 95% confidence interval is from .106 to .226. The 99% confidence interval is from .087 to .246

Question 4

Calculate the estimated effect of a criminal record for white applicants by comparing the callback rate in the treatment condition and the callback rate in the control condition. Create a 95% confidence interval around this estimate. Next, describe the estimate and confidence interval in a way that could be understood by a general audience.

```
t.test(white_applicants.norec$callback == 1,
       white_applicants.crim$callback == 1,
       conf.level = .95)
```

```
##
##  Welch Two Sample t-test
##
## data:  white_applicants.norec$callback == 1 and white_applicants.crim$callback == 1
## t = 3.5103, df = 282.36, p-value = 0.0005207
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  0.07613775 0.27052892
## sample estimates:
## mean of x mean of y
## 0.3400000 0.1666667
```

By analyzing the treatment effect we see that the difference-in-means is 0.1733333 which shows a significant increase in the callback rate for whites without a record. The confidence interval explains that 95% of all observation callback rates would fall between .076 and .27, according to the t-test calculation. ## Question 5

Assuming a null hypothesis that there is no difference in callback rates between white people with a criminal record and white people without a criminal record, what is the probability that we would observe a difference as large or larger than the one that we observed in a sample of this size?

```r
t.test(white_applicants.norec$callback == 1,
       white_applicants.crim$callback == 1,
       conf.level = .95)
```

```
##
##  Welch Two Sample t-test
##
## data:  white_applicants.norec$callback == 1 and white_applicants.crim$callback == 1
## t = 3.5103, df = 282.36, p-value = 0.0005207
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  0.07613775 0.27052892
## sample estimates:
## mean of x mean of y
## 0.3400000 0.1666667
```

According to the p-value in the t-test of .005207, there is a .5% probability that we would observe a larger difference than we observed in this sample size. ## Question 6

Imagine that we set up a hypothesis test where the null hypothesis is that there is no difference in callback rates between whites with and without a criminal record. In the context of this problem, what would it mean to commit a type I error? In the context of this problem, what would it mean to commit a type II error? If we set $\alpha = 0.05$ for a two-tailed test are we specifying the probability of type I error or type II error?

A type I error would be defined as a false positive which would reject the null hypothesis of there being no difference in callback rates. In this context, a Type I error would result in a difference between the callback rates of whites with and without criminal records.

A type II error would be defined as a false negative in which the null hypothesis is not rejected or a situation in which the difference in callback rates would be equal.

The alpha value would be specifying the probablity of a type I error.