Lab 1: Exploratory Data Analysis (EDA)

Statistics 139 (special thanks to Julie Vu!)

September 08, 2023

Topics

- Basic Data Cleaning
- Numerical and Graphical Summaries
- Subsetting Data

The data in the file 'dds_discrimination.csv' represent a sample of 1,000 residents of California who receive funds from the California Department of Developmental Services (DDS); individuals receiving funds are referred to as 'consumers'.

A study team examined the mean annual expenditure on consumers by ethnicity and found that the mean annual expenditures on Hispanic consumers was approximately one-third of the mean expenditures on White non-Hispanic consumers.

As a result, an allegation of ethnic discrimination was brought against the California DDS. Does this finding represent sufficient evidence of ethnic discrimination, or might there be more to the story?

The following variables are included in the dataset.

- `ID`: consumer ID number
- `Age.Cohort`: age group, where `1` refers to 0 - 5 years, `2` refers to 51+ years, `3` refers to 13 - 17 years, `4` refers to 18 - 21 years, `5` refers to 22 - 50 years, and `6` refers to 6 - 12 years.
- `Age`: age in years
- `Gender`: gender, recorded as `1` for female and `2` for male
- `Expenditures`: annual expenditure in dollars
- `Ethnicity`: ethnicity, recorded as either `1` for American Indian, `2` for Asian, `3` for Black, `4` for Hispanic, `5` for Multi Race, `6` for Native Hawaiian, `7` for Other, and `8` for White not Hispanic.

Problem 1: A little data clean-up

First, a bit of data cleaning will be helpful.

a) Read the file into R as the dds.discr dataframe, and examine the first few observations.

```
#read file into R
dds.discr <- read.csv("data/dds_discrimination.csv")
head(dds.discr)
```

```
##   X    ID Age.Cohort Age Gender Expenditures Ethnicity
## 1 1 10210          3  17      1         2113         8
## 2 2 10409          5  37      2        41924         8
## 3 3 10486          1   3      2         1454         4
## 4 4 10538          4  19      1         6400         4
## 5 5 10568          3  13      2         4412         8
## 6 6 10690          3  15      1         4566         4
```

b) The first column contains a ‘variable’ X that is just the row number as carried over from the CSV file. Run the following to eliminate X.

```
#remove first column
dds.discr[,1] <- NULL

#alternatively, we can give an extra argument into the read.csv function
dds.discr2 <- read.csv("data/dds_discrimination.csv", row.names=1)
head(dds.discr2)
```

```
##      ID Age.Cohort Age Gender Expenditures Ethnicity
## 1 10210          3  17      1         2113         8
## 2 10409          5  37      2        41924         8
## 3 10486          1   3      2         1454         4
## 4 10538          4  19      1         6400         4
## 5 10568          3  13      2         4412         8
## 6 10690          3  15      1         4566         4
```

c) Datasets can sometimes have variables with long or messy names. For the sake of practice, read the documentation for the colnames( ) function and change the names of the variables to ones you find more convenient. To access the R help files for a function, type ? before the function name.

```
# your work here

names(dds.discr) = c("id","age.cohort","age","gender","expenditures","ethnicity")
names(dds.discr)
```

```
## [1] "id"           "age.cohort"   "age"          "gender"       "expenditures"
## [6] "ethnicity"
```

d) Let’s look again at the dataset, this time using the str() function. What looks strange about the `gender` and `expenditures` variables? Hint: You’ve seen this in class already…

```
#maybe better to use str()
str(dds.discr)
```

```
## ’data.frame’:    1000 obs. of  6 variables:
##  $ id          : int  10210 10409 10486 10538 10568 10690 10711 10778 10820 10823 ...
##  $ age.cohort  : int  3 5 1 4 3 3 3 3 3 3 ...
##  $ age         : int  17 37 3 19 13 15 13 17 14 13 ...
##  $ gender      : chr  "1" "2" "2" "1" ...
##  $ expenditures: chr  "2113" "41924" "1454" "6400" ...
##  $ ethnicity   : int  8 8 4 4 8 4 8 3 8 4 ...
```

- Gender should be factor
- Expenditures should be numeric

Explain how the following two lines are designed to find the problems with the `gender` and `expenditures` variables, and explain what those problems are. You might have to read the documentation by typing `?` before any function names you don’t know.

```
# see what values the var gender takes on
table(dds.discr$gender)
```

```
##
##      1      2 female FEMALE   male   Male   MALE
##    500    494      2      1      1      1      1
```

```
# see what non-numeric values the var expenditures takes on
dds.discr$expenditures[which(is.na(as.numeric(dds.discr$expenditures)))]
```

```
## Warning in which(is.na(as.numeric(dds.discr$expenditures))): NAs introduced by
## coercion
```

```
## [1] "$46,571 " "$42,192 " "$54,616 " "$60,871 " "$3,673 "
```

Challenge: Explain how the following four lines of code fix the problem with the Expenditures variable. It’s ok if you can’t figure it out, this one is hard. You can just run the code for now.

```
# change gender var to uppercase
dds.discr.uppercase <- toupper(dds.discr$gender)

# if the value is MALE, change it to 2
dds.discr.uppercase[which(dds.discr.uppercase == "MALE")] <- "2"
```

```
# if the value is FEMALE, change it to 1
dds.discr.uppercase[which(dds.discr.uppercase == "FEMALE")] <- "1"

# change gender var to type numeric
dds.discr$gender <- as.numeric(dds.discr.uppercase)
```

Challenge: Explain how the following two lines of code fix the problem with the Expenditures variable. It's ok if you can't figure it out, this one is hard. You can just run the code for now.

```
# substitute $ for non-numeric values of Expenditure with blank character
dds.discr$expenditures[which(is.na(as.numeric(dds.discr$expenditures)))] <- gsub("\\$","",dds.d
```

```
## Warning in which(is.na(as.numeric(dds.discr$expenditures))): NAs introduced by
## coercion

## Warning in which(is.na(as.numeric(dds.discr$expenditures))): NAs introduced by
## coercion
```

```
# substitute , for non-numeric values of Expenditure with blank character
dds.discr$expenditures[which(is.na(as.numeric(dds.discr$expenditures)))] <- gsub(",","",dds.dis
```

```
## Warning in which(is.na(as.numeric(dds.discr$expenditures))): NAs introduced by
## coercion

## Warning in which(is.na(as.numeric(dds.discr$expenditures))): NAs introduced by
## coercion
```

```
# change Expenditures var to type numeric
dds.discr$expenditures <- as.numeric(dds.discr$expenditures)
```

e) The categorical variables (age cohort, gender, and ethnicity) should be converted to factor variables. Read the documentation for `factor( )` and recode these three variables. Note that age cohort is an ordered categorical variable.

```
summary(dds.discr)
```

```
##        id          age.cohort         age            gender       expenditures
##  Min.   :10210   Min.   :1.000   Min.   : 0.0   Min.   :1.000   Min.   :  222
##  1st Qu.:31809   1st Qu.:3.000   1st Qu.:12.0   1st Qu.:1.000   1st Qu.: 2899
##  Median :55384   Median :4.000   Median :18.0   Median :1.000   Median : 7026
##  Mean   :54663   Mean   :3.906   Mean   :22.8   Mean   :1.497   Mean   :18066
##  3rd Qu.:76135   3rd Qu.:5.000   3rd Qu.:26.0   3rd Qu.:2.000   3rd Qu.:37713
##  Max.   :99898   Max.   :6.000   Max.   :95.0   Max.   :2.000   Max.   :75098
##    ethnicity
##  Min.   :1.000
##  1st Qu.:4.000
##  Median :4.000
##  Mean   :5.313
##  3rd Qu.:8.000
##  Max.   :8.000
```

```
dds.discr$gender =  factor(dds.discr$gender, levels=1:2, labels=c("F","M"))

dds.discr$age.cohort = factor(dds.discr$age.cohort, levels = c(1,6,3,4,5,2),
                                  labels=c("0-5","6-12","13-17","18-21","22-50","51+"))

dds.discr$ethnicity =  factor(dds.discr$ethnicity, levels=1:8, labels=c("American Indian","Asia
```

f) Save the clean version of the dataframe as an `.Rdata` file. (Alternatively, you could use `write.csv( )` to write the dataframe to a CSV file.)

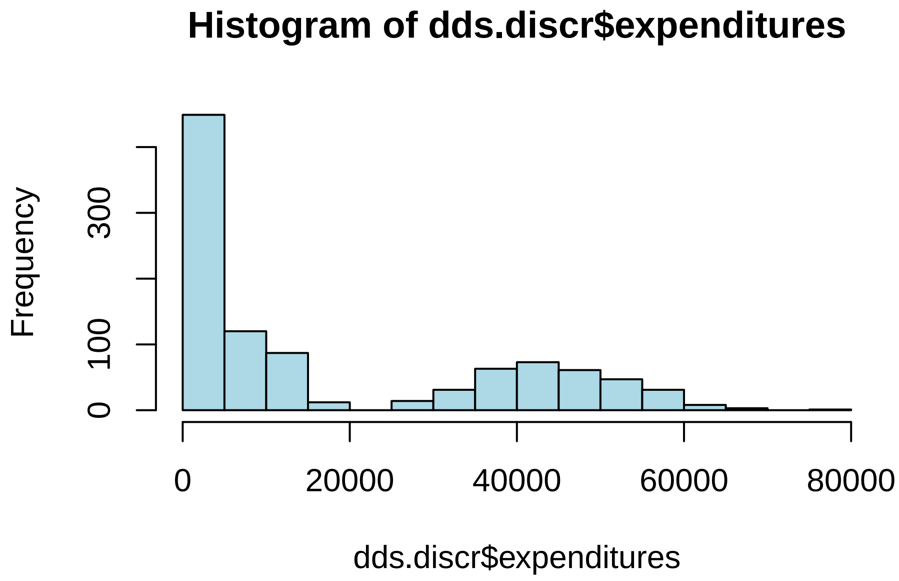
```
#save the file
save(dds.discr, file = "dds_discr.Rdata")
```

Problem 2: Univariate Explorations (aka, distributions)

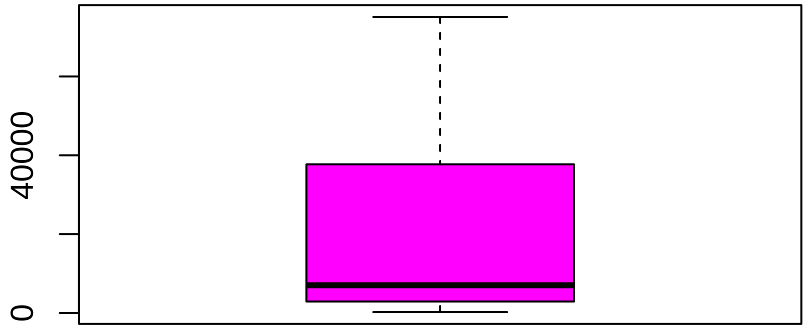
Let's start by examining the distributions of single variables on their own. Create numerical and graphical summaries as appropriate.

a) Describe the distribution of annual expenditures. For most consumers, is the amount of financial support provided by the DDS relatively high or low?

```
#graphical summaries
hist(dds.discr$expenditures,col="lightblue")
```



```
boxplot(dds.discr$expenditures, col="magenta")
```



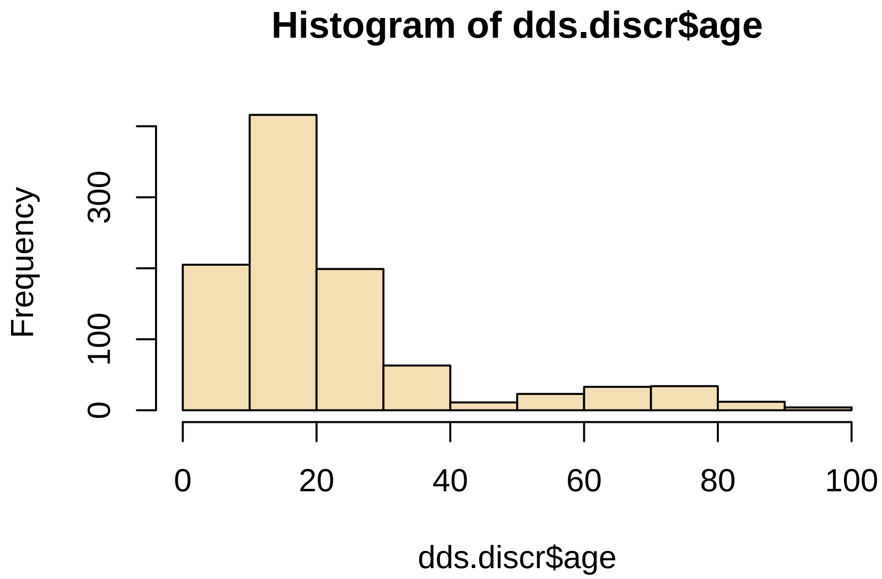
```
#numerical summaries
summary(dds.discr$expenditures)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     222    2899    7026   18066   37713   75098
```

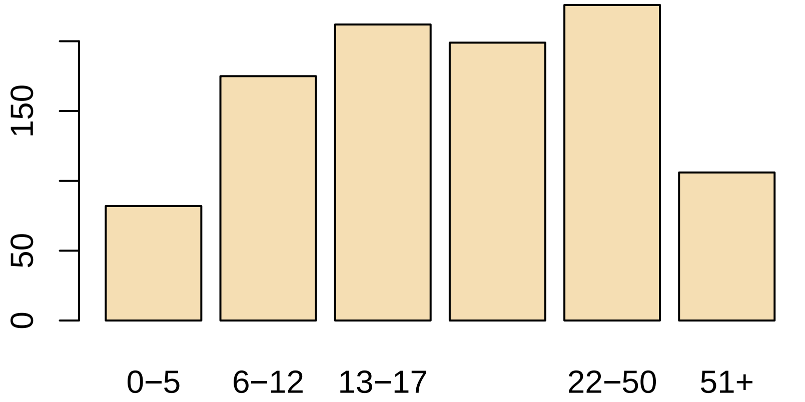
- For most consumers, the amount of financial support tends to be low (right skewed distribution)

  b) Do consumers tend to be older or younger?

```
#graphical summaries
hist(dds.discr$age, col = "wheat")
```



```
plot(dds.discr$age.cohort, col = "wheat")
```



```
#numerical summaries
summary(dds.discr$age)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     0.0    12.0    18.0    22.8    26.0    95.0
```

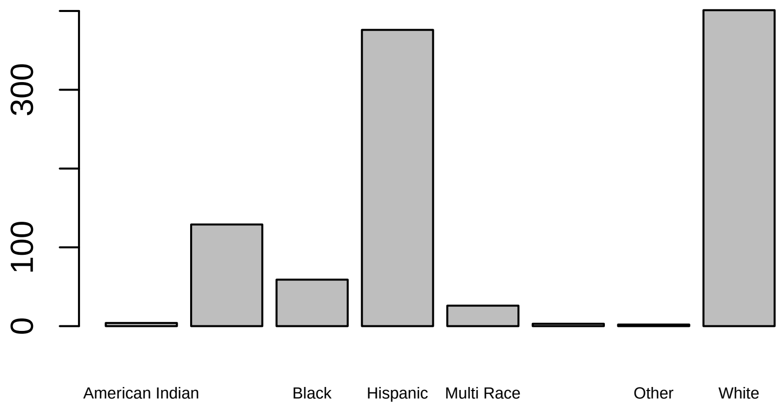
```
table(dds.discr$age.cohort)
```

```
##
##   0-5  6-12 13-17 18-21 22-50   51+
##    82   175   212   199   226   106
```

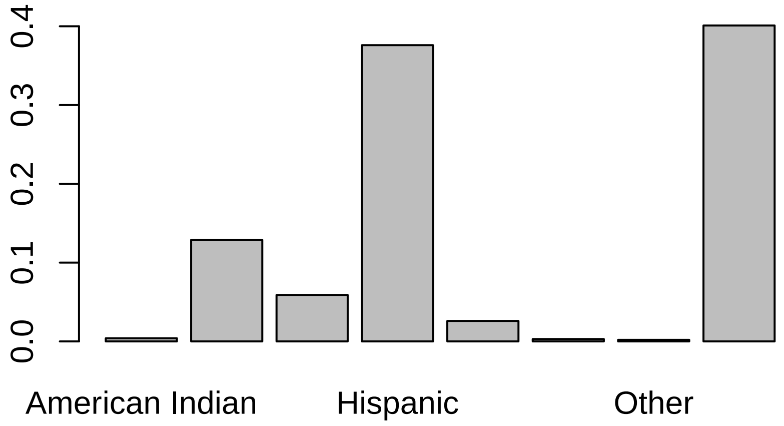
- Consumers tend to be younger (also right skewed distribution)

c) Is there an equal representation among ethnic groups?

```
#graphical summaries
barplot(table(dds.discr$ethnicity), cex.names = 0.5)
```



```
barplot(prop.table(table(dds.discr$ethnicity)))
```



```
#numerical summaries
table(dds.discr$ethnicity)
```

```
##
## American Indian           Asian           Black        Hispanic      Multi Race
##               4             129              59             376              26
## Native Hawaiian           Other           White
##               3               2             401
```

```
prop.table(table(dds.discr$ethnicity))
```

```
##
## American Indian           Asian           Black        Hispanic      Multi Race
##           0.004           0.129           0.059           0.376           0.026
## Native Hawaiian           Other           White
##           0.003           0.002           0.401
```

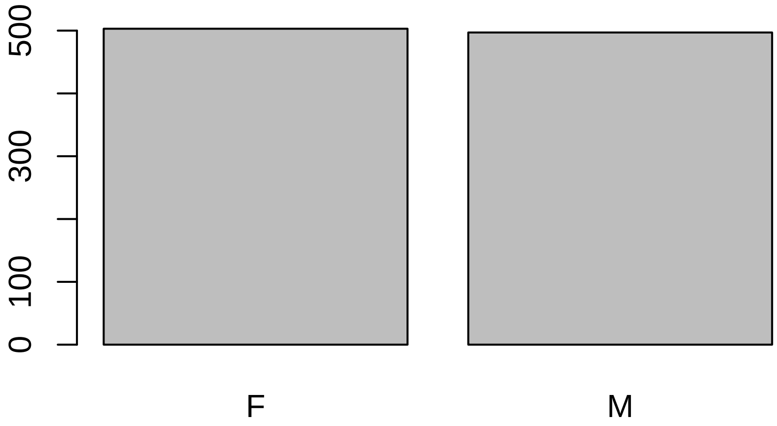
```
mean(dds.discr$ethnicity == "White" | dds.discr$ethnicity == "Hispanic")
```

```
## [1] 0.777
```

- can't tell bc we don't know the actual % breakdown of ethnicity of people in the US
- not equal because White and Hispanic consumers make up 77% of the group

d) Does gender appear to be balanced?

```
#graphical summaries
plot(dds.discr$gender)
```



```
table(dds.discr$gender)
```

```
##
##   F   M
## 503 497
```

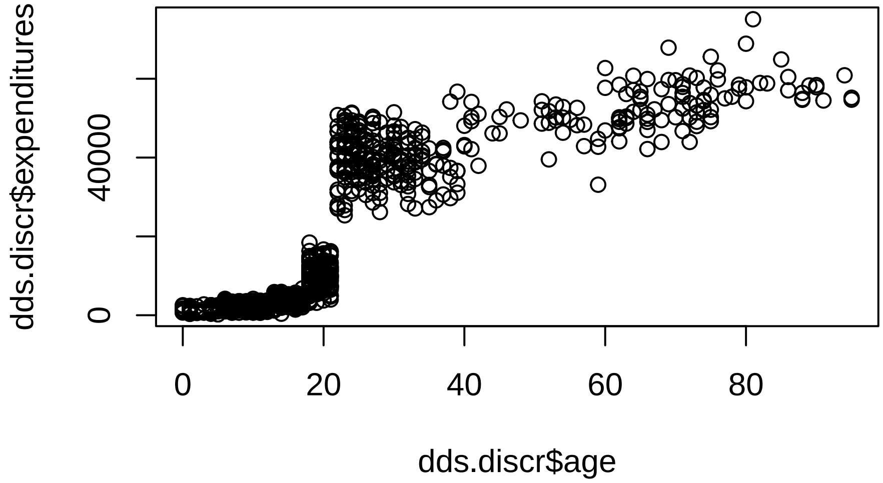
```
* balanced!
```

Problem 3: Bivariate Explorations (aka, relationships)

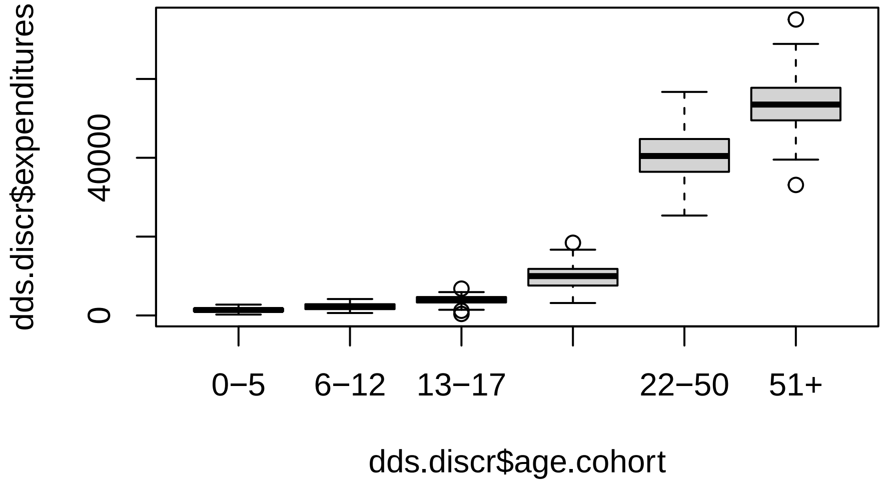
Let's explore how variables are related to each other.

a) How do annual expenditures vary by age? Explore this using the quantitative and categorical versions of age separately. Conjecture a reason for the trend in the data.

```
# graphical
plot(dds.discr$expenditures ~ dds.discr$age)
```



```
plot(dds.discr$expenditures ~ dds.discr$age.cohort)
```



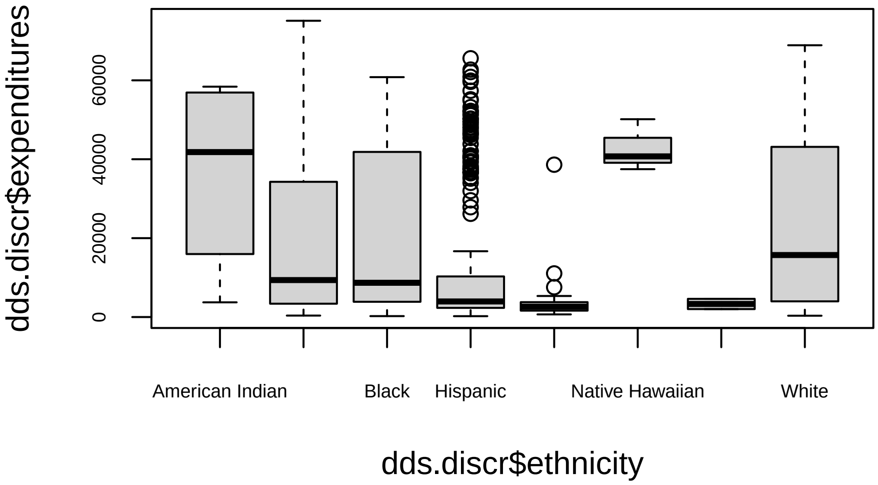
```
# numerical
tapply(dds.discr$expenditures, dds.discr$age.cohor, summary)
```

```
## $`0-5`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     222    1034    1380    1415    1739    2750
##
## $`6-12`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     620    1602    2191    2227    2846    4163
##
## $`13-17`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     386    3306    3952    3923    4666    6798
##
## $`18-21`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    3153    7588    9979    9889   11806   18435
##
## $`22-50`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   25348   36447   40456   40209   44721   56716
##
## $`51+`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   33110   49515   53509   53522   57746   75098
```

```
* People aged 22+ have more expenditures than 21 and below consumers. This could be due to hig
```

b) How does the distribution of expenditures vary by ethnic group?

```r
# graphical
boxplot(dds.discr$expenditures ~ dds.discr$ethnicity, cex.axis = 0.6)
```



```
# numerical
tapply(dds.discr$expenditures, dds.discr$ethnicity, summary)
```

```
## $‘American Indian‘
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    3726   22085   41818   36438   56170   58392
##
## $Asian
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     374    3382    9369   18392   34274   75098
##
## $Black
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     240    3870    8687   20885   41857   60808
##
## $Hispanic
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     222    2331    3952   11066   10292   65581
##
## $‘Multi Race‘
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     669    1690    2622    4457    3750   38619
##
## $‘Native Hawaiian‘
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   37479   39103   40727   42782   45434   50141
##
## $Other
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
##    2018    2667    3316    3316    3966    4615 
## 
## $White
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
##     340    3977   15718   24698   43134   68890
```

```
* The Hispanic group has many outliers.
* American Indian and Native Hawaiian groups have the highest average expenditures
```

Problem 4: Exploring Evidence of Discrimation

Hispanic and White non-Hispanic individuals comprise the majority of the data. The rest of this analysis will focus on comparing how expenditures vary between these two groups.

a) Do Hispanic consumers, on average, seem to receive less financial support from the California DDS than a White non-Hispanic consumer?

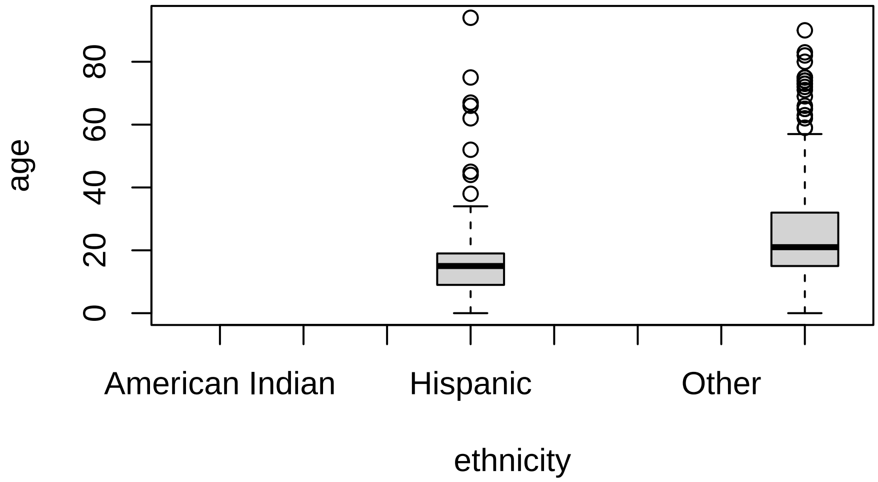
```
tapply(dds.discr$expenditures, dds.discr$ethnicity, mean)
```

```
## American Indian           Asian           Black        Hispanic      Multi Race 
##       36438.250       18392.372       20884.593       11065.569        4456.731 
## Native Hawaiian           Other           White 
##       42782.333        3316.500       24697.549
```

```
* Hispanic consumers tend to receive ~$11k on average, less than White consumers ($25k on avera
```

b) Recall that expenditures is strongly associated with age. Is there also an association between age and ethnicity, for these two ethnic groups?

```
plot(age~ethnicity, dds.discr[dds.discr$ethnicity == c("White", "Hispanic"),])
```



c) For a closer look at the relationship between age, ethnicity, and expenditures, compare how average expenditures differ by ethnic group within each age cohort. Describe your findings.

```
with(dds.discr[dds.discr$ethnicity == c("White", "Hispanic"),], tapply(expenditures, list(ethni
```

```
##                       0-5      6-12     13-17     18-21    22-50      51+
## American Indian        NA        NA        NA        NA       NA       NA
## Asian                  NA        NA        NA        NA       NA       NA
## Black                  NA        NA        NA        NA       NA       NA
## Hispanic         1478.864  2469.079  3890.200  9497.625 40586.39 56303.00
## Multi Race             NA        NA        NA        NA       NA       NA
## Native Hawaiian        NA        NA        NA        NA       NA       NA
## Other                  NA        NA        NA        NA       NA       NA
## White            1220.000  2201.889  3727.879  9907.139 40344.14 51991.36
```

d) Does there seem to be evidence of ethnic discrimination in the amount of financial support provided by the California DDS? Explain why the bivariate analysis conducted by the study team was misleading (bonus for remembering the specific term for the responsible phenomenon, which was covered in Stat 110!).

- Simpson’s paradox