Example 6

First let's read in the data.

```
dat<-read.csv("homework6.csv")
```

Next we'll check the structure.

```
str(dat)
```

```
## 'data.frame':    48 obs. of  5 variables:
##  $ rt         : num  348 309 291 333 315 ...
##  $ type       : Factor w/ 2 levels "conjunction",..: 2 2 2 2 2 2 2 2 2 2 ...
##  $ distractors: int  4 4 4 4 4 4 4 4 8 8 ...
##  $ subject    : int  1 2 3 4 5 6 7 8 1 2 ...
##  $ subject2   : int  1 2 3 4 5 6 7 8 1 2 ...
```

The data fram contains response times for different types of searches with different numbers of distractors with two different subject variables. However the distractor and subject variables aren't factors so we need to change that.

```
dat$distractors <- as.factor(dat$distractors)
dat$subject <- as.factor(dat$subject)
dat$subject2 <- as.factor(dat$subject2)
```

Now we'll run a one-way between-subjects ANOVA to see if the number of distracctors affected response times for conjunction searches only.

```
summary(aov(rt~distractors, data = dat[dat$type=="conjunction",]))
```

```
##             Df Sum Sq Mean Sq F value  Pr(>F)
## distractors  2  14078    7039   8.603 0.00187 **
## Residuals   21  17182     818
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

According to the results of the ANOVA the number of distractors affected how long it took people to complete conjunction searches, $F(2,21) = 8.6$, $p = .002$. Let's create a line graph to see how the distractors affected response times. First we'll need to load our graphics libraries.

```
library(ggplot2)
library(gplots)
```

```
##
## Attaching package: 'gplots'
##
## The following object is masked from 'package:stats':
##
##     lowess
```

```
library(dplyr)
```

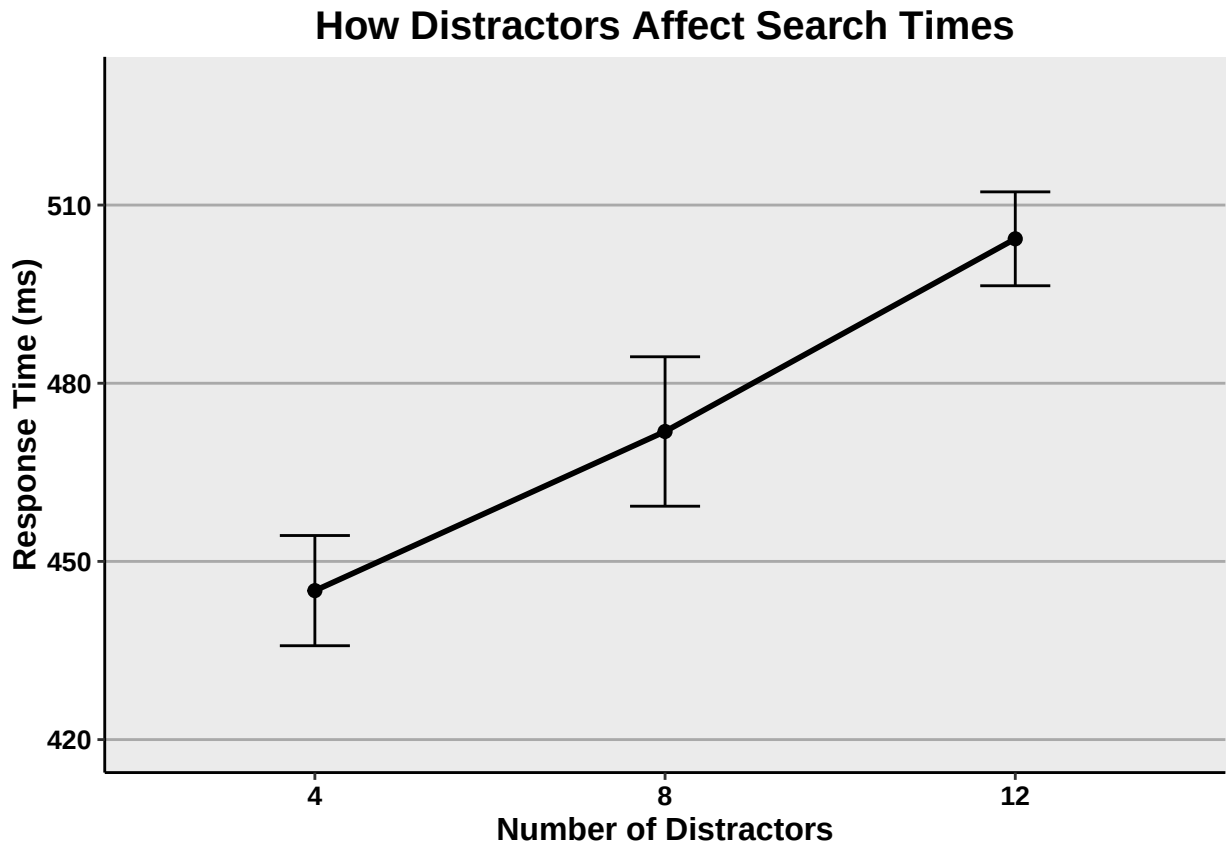
```
##
## Attaching package: 'dplyr'
##
## The following objects are masked from 'package:stats':
##
##     filter, lag
##
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

Next we'll need to compute the means and standard errors for our graph.

```
temp<-dat[dat$type=="conjunction",]%>%group_by(distractors)%>%
  summarize(means=mean(rt),
            sems=sd(rt)/sqrt(length(rt)))
```

Finally, we'll create our line graph.

```
f<-ggplot(temp, aes(x=as.factor(distractors),
                    y=means,
                    group=1))+
  geom_line(size=1)+
  geom_point(size=2)+
  geom_errorbar(aes(ymax=means+sems,
                    ymin=means-sems),
                width=.2)+
  ggtitle("How Distractors Affect Search Times")+
  labs(x="Number of Distractors",y="Response Time (ms)")+
  theme(plot.title=element_text(size=15,face="bold",vjust=.5))+
  theme(axis.title.x=element_text(size=12,face="bold",vjust=-.25))+
  theme(axis.title.y=element_text(size=12,face="bold",vjust=1))+
  theme(axis.text.x=element_text(size=10,face="bold",color="black"))+
  theme(axis.text.y=element_text(size=10,face="bold",color="black"))+
  coord_cartesian(ylim=c(min(temp$means)-2*max(temp$sems),
                         max(temp$means)+2*max(temp$sems)))+
  theme(panel.border=element_blank(),axis.line=element_line())+
  theme(panel.grid.major.x=element_blank())+
  theme(panel.grid.major.y=element_line(color="darkgrey"))+
  theme(panel.grid.minor.y=element_blank())
f
```



From this figure and the results of the ANOVA, it's clear that the more distractors there are, the more time it takes to complete the searches.

As a demonstration, I'll also conduct a one-way within-subjects ANOVA.

```
summary(aov(rt~distractors + Error(subject/distractors),
            data = dat[dat$type=="conjunction",]))
```

```
##
## Error: subject
##           Df Sum Sq Mean Sq F value Pr(>F)
## Residuals  7  15437    2205
##
## Error: subject:distractors
##             Df Sum Sq Mean Sq F value   Pr(>F)
## distractors  2  14078    7039   56.45 1.99e-07 ***
## Residuals   14   1746     125
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

The results of this test also indicate that response times increase with increasing distractors, $F(2,14) = 56.5$, $p < .05$.

Here, I'm going to perform a between-subjects ANOVA to examine the effects and interactions between the number of distractors and the search type.

```
summary(aov(rt~type*distractors, data = dat))
```

```
##                   Df Sum Sq Mean Sq F value  Pr(>F)
## type               1 342239  342239 459.417 < 2e-16 ***
## distractors        2   3945    1972   2.648 0.08262 .
## type:distractors   2  11675    5838   7.836 0.00128 **
## Residuals         42  31288     745
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

There's a significant effect of search type, $F(1,42) = 459.4$, $p < .05$. There's no effect of the type of distractors, $F(2,42) = 2.6$, $p = .083$. There was an interaction between the type of search and number of distractors, $F(2,42) = 7.8$, $p = .001$.

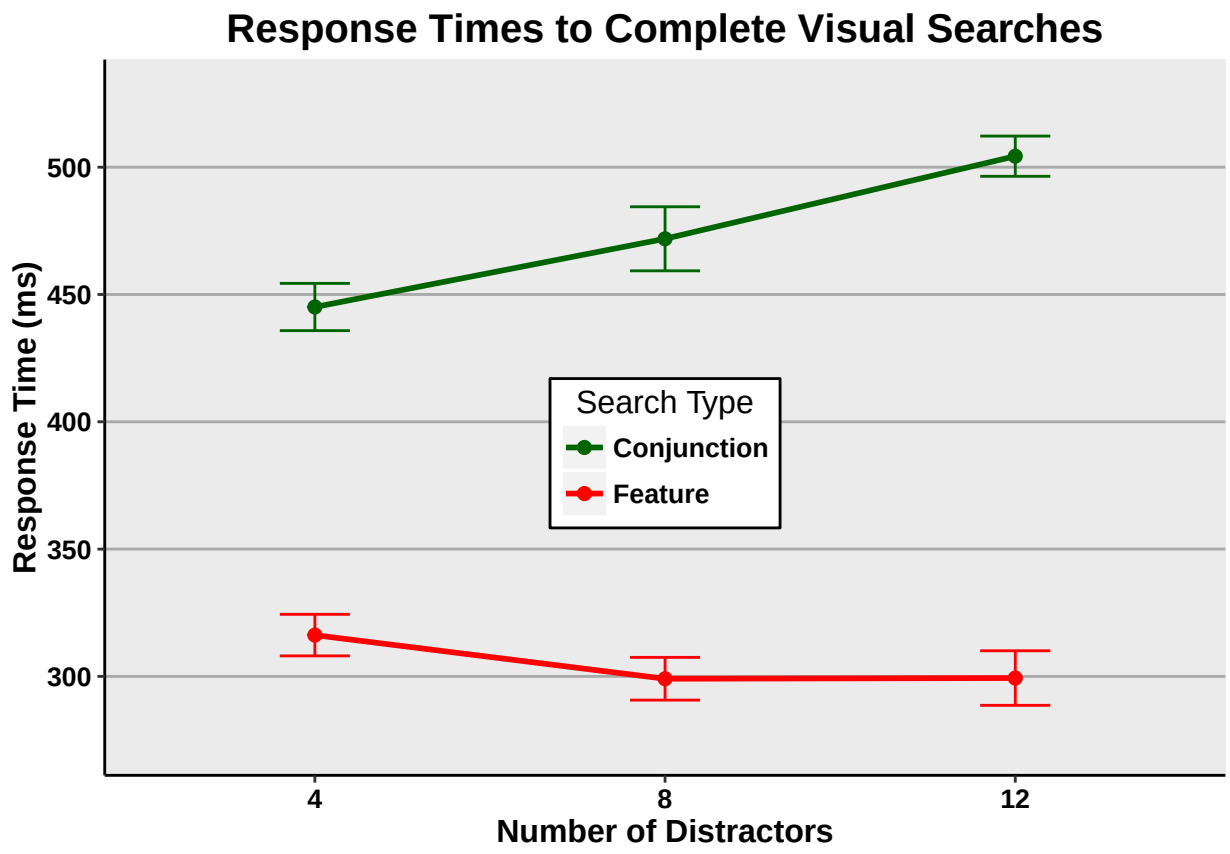
To better understand the effect of type and the interaction, I'll plot a line graph and a grouped bar graph. But first we need to summarize the data before we can plot it.

```
temp<-dat%>%group_by(type,distractors)%>%
  summarize(means=mean(rt),
            sems=sd(rt)/sqrt(length(rt)))
```

Now I can create the figures.

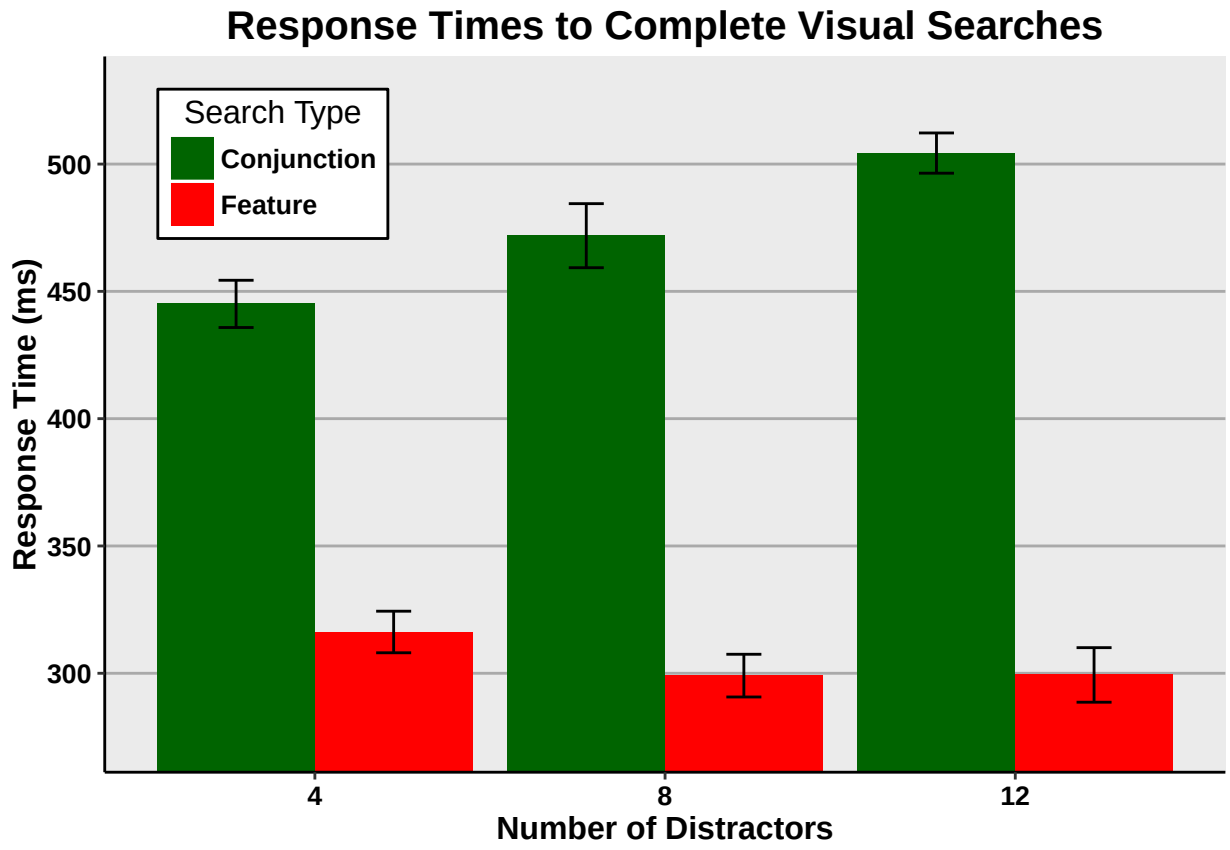
```
f<-ggplot(temp, aes(x=distractors,
                    y=means,
                    group=type,
                    color=type))+
  geom_line(size=1)+
  geom_point(size=2)+
  scale_color_manual(values=c("darkgreen","red"),
                     name="Search Type",
                     breaks=c("conjunction","feature"),
                     labels=c("Conjunction", "Feature"))+
  geom_errorbar(aes(ymax=means+sems, ymin=means-sems),width=.2)+
  ggtitle("Response Times to Complete Visual Searches")+
  labs(x="Number of Distractors",y="Response Time (ms)")+
  theme(plot.title=element_text(size=15,face="bold",vjust=.5))+
  theme(axis.title.x=element_text(size=12,face="bold",vjust=-.25))+
  theme(axis.title.y=element_text(size=12,face="bold",vjust=1))+
  theme(axis.text.x=element_text(size=10,face="bold",color="black"))+
  theme(axis.text.y=element_text(size=10,face="bold",color="black"))+
  coord_cartesian(ylim=c(min(temp$means)-2*max(temp$sems),
                         max(temp$means)+2*max(temp$sems)))+
  theme(panel.border=element_blank(),axis.line=element_line())+
  theme(panel.grid.major.x=element_blank())+
  theme(panel.grid.major.y=element_line(color="darkgrey"))+
  theme(panel.grid.minor.y=element_blank())+
  theme(legend.position=c(.5,.45))+
  theme(legend.background=element_blank())+
  theme(legend.background=element_rect(color="black"))+
  theme(legend.title=element_blank())+
  theme(legend.title=element_text(size=12))+
  theme(legend.title.align=.5)+
```

```
  theme(legend.text=element_text(size=10,face="bold"))
f
```




```
f<-ggplot(temp, aes(x=distractors,
                    y=means,
                    fill=type))+
  geom_bar(stat="identity",position=position_dodge())+
  scale_fill_manual(values=c("darkgreen","red"),
                     name="Search Type",
                     breaks=c("conjunction","feature"),
                     labels=c("Conjunction", "Feature"))+
  geom_errorbar(aes(ymax=means+sems,
                    ymin=means-sems),
                width=.2,
                position=position_dodge(.9))+
  ggtitle("Response Times to Complete Visual Searches")+
  labs(x="Number of Distractors",y="Response Time (ms)")+
  theme(plot.title=element_text(size=15,face="bold",vjust=.5))+
  theme(axis.title.x=element_text(size=12,face="bold",vjust=-.25))+
  theme(axis.title.y=element_text(size=12,face="bold",vjust=1))+
  theme(axis.text.x=element_text(size=10,face="bold",color="black"))+
  theme(axis.text.y=element_text(size=10,face="bold",color="black"))+
  coord_cartesian(ylim=c(min(temp$means)-2*max(temp$sems),
                         max(temp$means)+2*max(temp$sems)))+
  theme(panel.border=element_blank(),axis.line=element_line())+
```

```
  theme(panel.grid.major.x=element_blank())+
  theme(panel.grid.major.y=element_line(color="darkgrey"))+
  theme(panel.grid.minor.y=element_blank())+
  theme(legend.position=c(.15,.85))+
  theme(legend.background=element_blank())+
  theme(legend.background=element_rect(color="black"))+
  theme(legend.title=element_blank())+
  theme(legend.title=element_text(size=12))+
  theme(legend.title.align=.5)+
  theme(legend.text=element_text(size=10,face="bold"))
f
```



Based on the results and the figure, it's clear that conjunction searches take more time to complete when there are more distractors. However, for feature searches the number of distractors doesn't have much of an effect on the time to complete the searches.

Now I'm going to perform a within-subjects two-way ANOVA on the data I've already analyzed above.

```
summary(aov(rt~type*distractors+Error(subject/(type*distractors)), data = dat))
```

```
##
## Error: subject
##           Df Sum Sq Mean Sq F value Pr(>F)
## Residuals  7  24790    3541
##
## Error: subject:type
```

```
##           Df Sum Sq Mean Sq F value  Pr(>F)
## type       1 342239  342239    1626 1.5e-09 ***
## Residuals  7   1473     210
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Error: subject:distractors
##             Df Sum Sq Mean Sq F value  Pr(>F)
## distractors  2   3945  1972.3   11.16 0.00127 **
## Residuals   14   2475   176.8
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Error: subject:type:distractors
##                   Df Sum Sq Mean Sq F value   Pr(>F)
## type:distractors  2  11675    5838   32.05 5.95e-06 ***
## Residuals        14   2550     182
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

According to these results and interpreted in light of the figures, conjunction searches took more time than feature searches $F(1,7) = 1626$, $p < .05$. Searches with more distractors generally took longer to complete, $F(2,14) = 11.2$, $p = .001$. Finally, distractors had a greater effect for conjunction searches, $F(2,14) = 32.0$, $p < .05$.

Finally, I'm going to conduct a mixed ANOVA where the type of search varies across subjects and the number of distractors varies within.

```
summary(aov(rt~type*distractors+Error(subject2/distractors), data = dat))
```

```
##
## Error: subject2
##           Df Sum Sq Mean Sq F value   Pr(>F)
## type       1 342239  342239   182.4 2.02e-09 ***
## Residuals 14  26263    1876
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Error: subject2:distractors
##                   Df Sum Sq Mean Sq F value   Pr(>F)
## distractors        2   3945    1972   10.99    3e-04 ***
## type:distractors  2  11675    5838   32.53 4.98e-08 ***
## Residuals        28   5025     179
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

According to these results, conjunction searches took more time than feature searches, $F(1,14) = 182.4$, $p < .05$. As the number of distractors increased, search times generally increased, $F(2,28) = 11.0$, $p < .05$. Finally search times increased distractors for conjunction, but not for feature searches, $F(2,28) = 32.5$, $p < .05$.