Chapter 9: Advanced Plotting

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Introduction

Good Quote

“The commonality between science and art is in trying to see profoundly - to develop strategies of seeing and showing.”
— Edward Tufte

Introduction

Once again, we will turn to our friend `ggplot2` to plot; but now, we are going to take it to another level. We will use many of the options that this powerful package provides and discuss briefly some important aspects of a good plot.

We will go through several aspects of the code that makes plotting in `R` flexible and beautiful.

1. Types of plots
2. Color schemes
3. Themes
4. Labels and titles
5. Facetting

Introduction

To highlight these features we'll be using our NHANES data again; specifically, sedentary behavior, depression, asthma, family size, and race. As this is only an introduction, refer to http://docs.ggplot2.org/current/ for more information on `ggplot2`.

Introduction

To begin, it needs to be understood that the first line where we actually use the ggplot function, will then apply to all subsequent laters (e.g., geom_point()). For example,

```
ggplot(df, aes(x = dep, y = sed, group = asthma))
```

means for the rest of the layers, unless we over-ride it, each will use df with dep as the x variable, sed as the y, and a grouping on asthma. So when many layers are going to use the same command put it in this so you don't have to write the same argument many times. A common one here could be:

```
ggplot(df, aes(x = dep, y = sed,
               group = asthma,
               color = asthma))
```

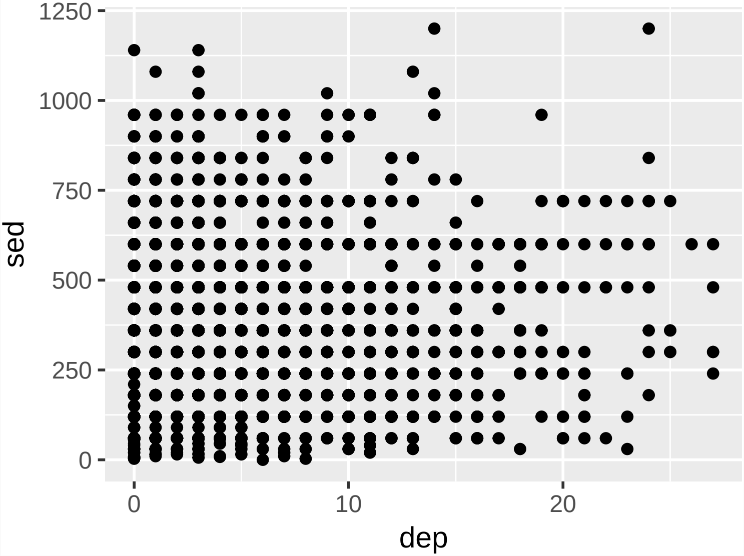
since we often want to color by our grouping variable.

Incomplete Plots

Before going forward, a nice feature of `ggplot2` allows us to use an "incomplete" plot to add on to. For example, if we have a good idea of the main structure of the plot but want to explore some changes, we can do the following:

```
p1 <- ggplot(df, aes(x = dep, y = sed, group = asthma)) +
  geom_point()
p1
```

Incomplete Plots



So now p1 has the information for this basic, and honestly fairly uninformative, plot. We'll use this feature to build on plots that we like.

Data Prep

Some of our figures will also need summary data so we'll start that here as well:

```
summed_data <- df %>%
  group_by(asthma, dep2) %>%
  summarize(s_se = sd(sed, na.rm=TRUE)/sqrt(n()),
            sed  = mean(sed, na.rm=TRUE),
            N    = n())
```

As you hopefully recognize a bit, we are summarizing the time spent being sedentary by both asthma and the dichotomous depression variables. If it doesn't make sense at first, read it line by line to see what I did. This will be useful for several types of plots.

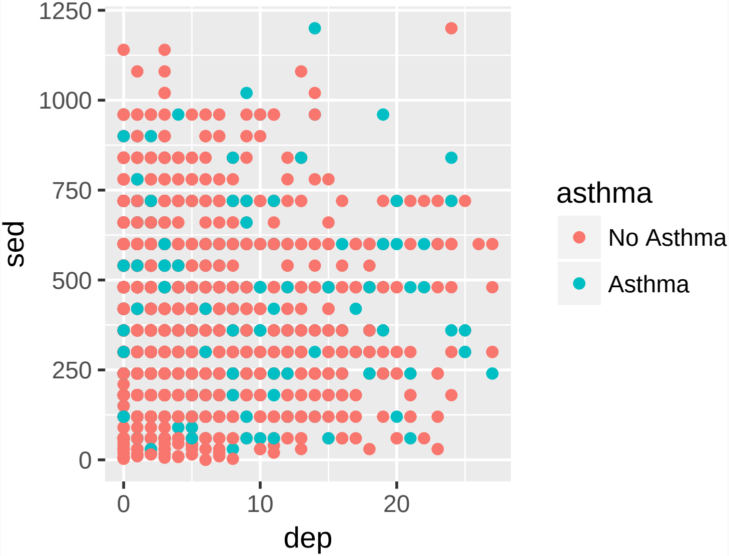
Types of Plots

Scatterplots

We'll start with a scatterplot–one of the most simple yet informative plots.

```r
ggplot(df, aes(x = dep, y = sed,
               group = asthma)) +
  geom_point(aes(color = asthma))
```

Scatterplots

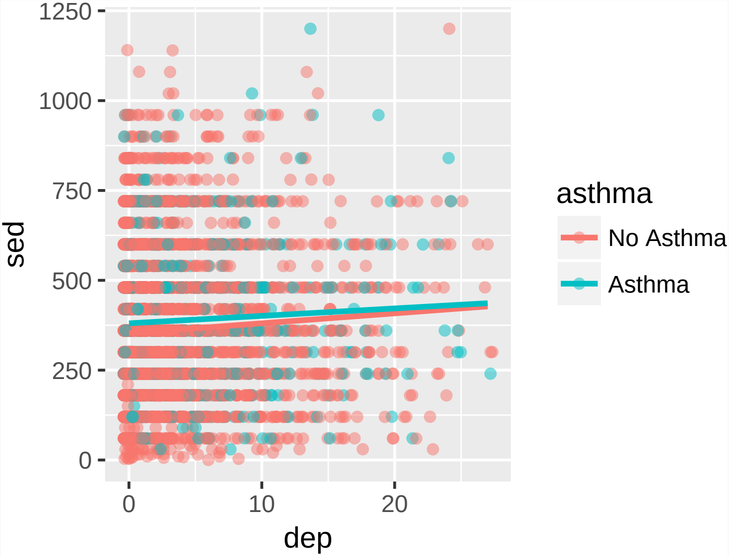


Scatterplots

It's not amazing. There looks to be a lot of overlap of the points. Also, it would be nice to know general trend lines for each group. Below, `alpha` refers to how transparent the points are, `method = "lm"` refers to how the line should be fit, and `se=FALSE` tells it not to include error ribbons.

```r
ggplot(df, aes(x = dep, y = sed, group = asthma)) +
  geom_jitter(aes(color = asthma), alpha = .5) +
  geom_smooth(aes(color = asthma),
              method = "lm", se=FALSE)
```

Scatterplots



Scatterplots

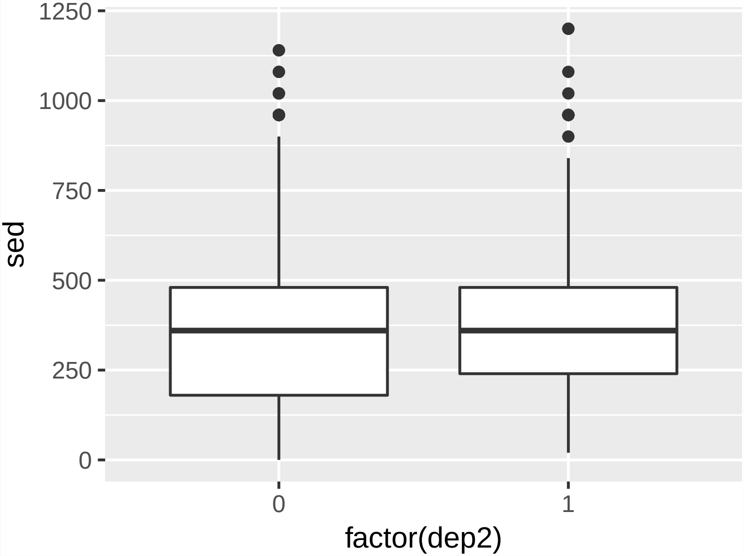
It’s getting better but we could still use some more features. We’ll come back to this in the next sections.

Boxplots

Box plots are great ways to assess the variability in your data. Below, we create a boxplot but change p1's x variable so that it is the factor version of depression.

```r
ggplot(df, aes(x = factor(dep2), y = sed)) +
  geom_boxplot()
```

Boxplots

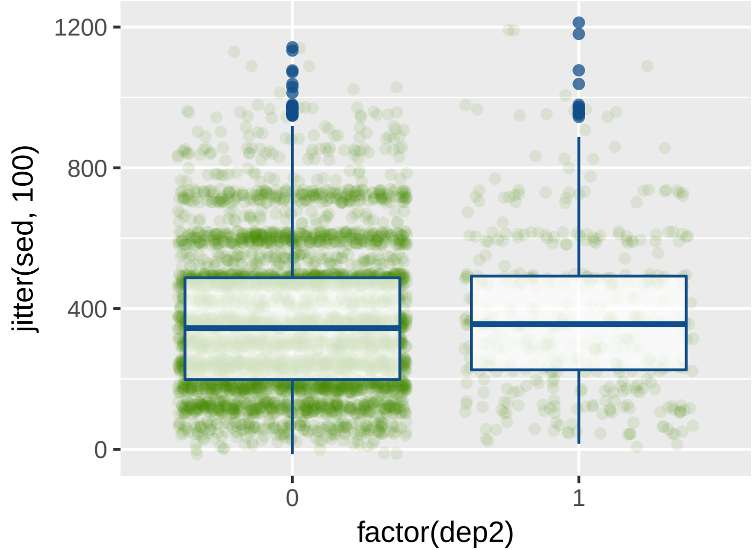


Boxplots

This plot is, at best, mediocre. But there's more we can do.

```r
ggplot(df, aes(x = factor(dep2), y = jitter(sed, 100))) +
  geom_jitter(alpha = .1, color = "chartreuse4") +
  geom_boxplot(alpha = .75, color = "dodgerblue4")
```

Boxplots



Boxplots

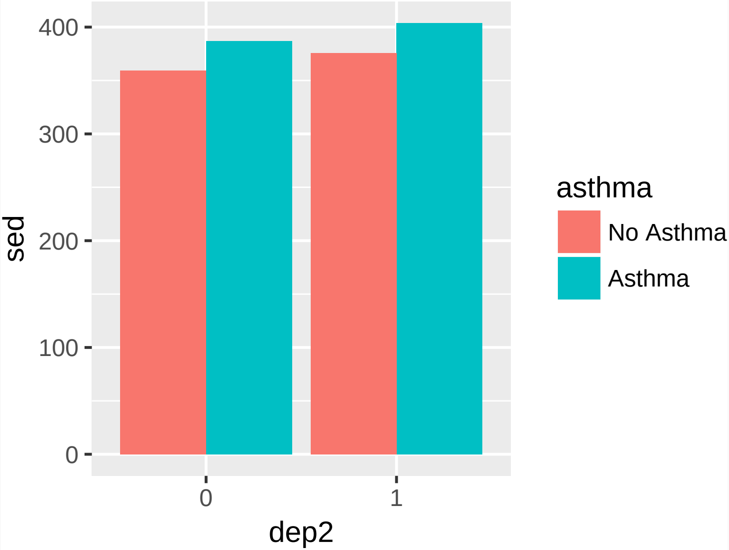
This now provides the (jittered) raw data points as well to hightlight the noise and the number of observations in each group.

Bar Plots

Bar plots are great ways to look at means and standard deviations for groups.

```r
ggplot(summed_data, aes(x = dep2, y = sed,
                        group = asthma)) +
  geom_bar(aes(fill = asthma),
           stat = "identity",
           position = "dodge")
```

Bar Plots



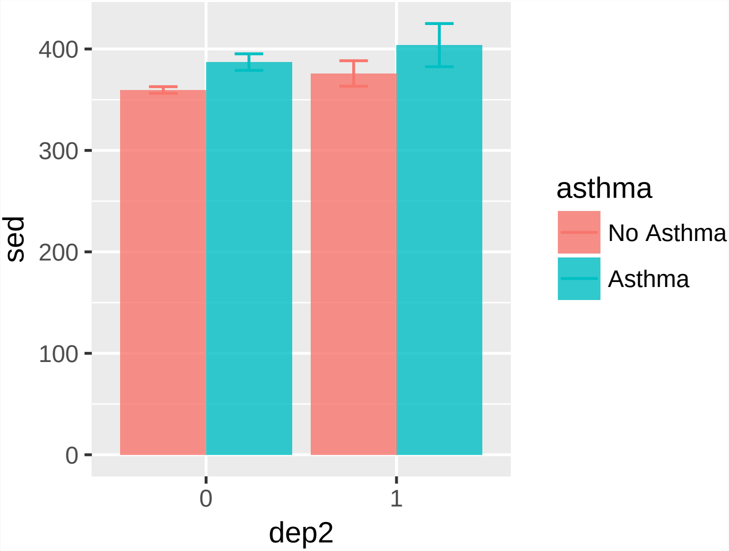
Bar Plots

We used `stat = "identity"` to make it based on the mean (default is `count`), and `position = "dodge"` makes it so the bars are next to each other as opposed to stacked. Let's also add error bars.

Bar Plots

```r
p = position_dodge(width = .9)
ggplot(summed_data, aes(x = dep2, y = sed,
                        group = asthma)) +
  geom_bar(aes(fill = asthma),
           stat = "identity",
           position = p,
           alpha = .8) +
  geom_errorbar(aes(ymin = sed - s_se, ymax = sed + s_se,
                    color = asthma),
                position = p,
                width = .3)
```

Bar Plots



Bar Plots

There's a lot in there but much of it is what you've seen before. For example, we use `alpha` in the `geom_bar()` to tell it to be slightly transparent so we can see the error bars better. We used the `position_dodge()` function to specify exactly how much dodge we wanted. In this way, we are able to line up the error bars and the bars. If we just use `position = "dodge"` we have less flexibility and control.

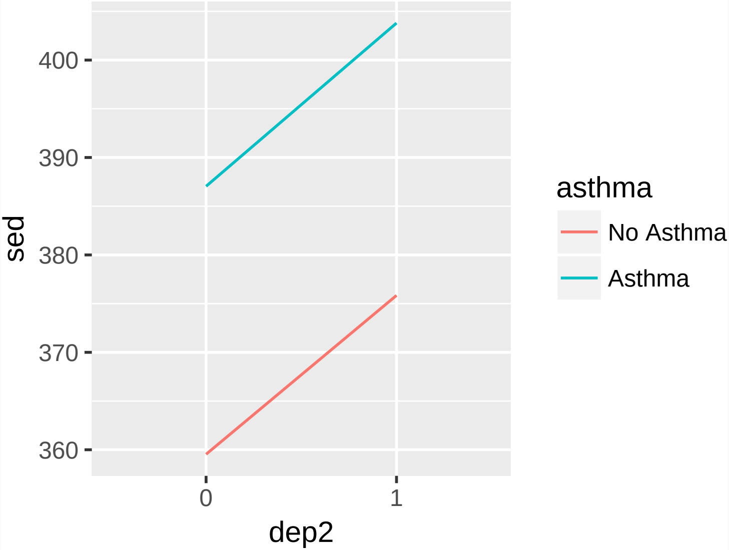
Much more can be done to clean this up, which we'll show in later sections.

Line Plots

Line plots are particularly good at showing trends and relationships. Below we we use it to highlight the relationship between depression, sedentary behavior, and asthma.

```r
ggplot(summed_data, aes(x = dep2, y = sed,
                        group = asthma)) +
  geom_line(aes(color = asthma))
```

Line Plots

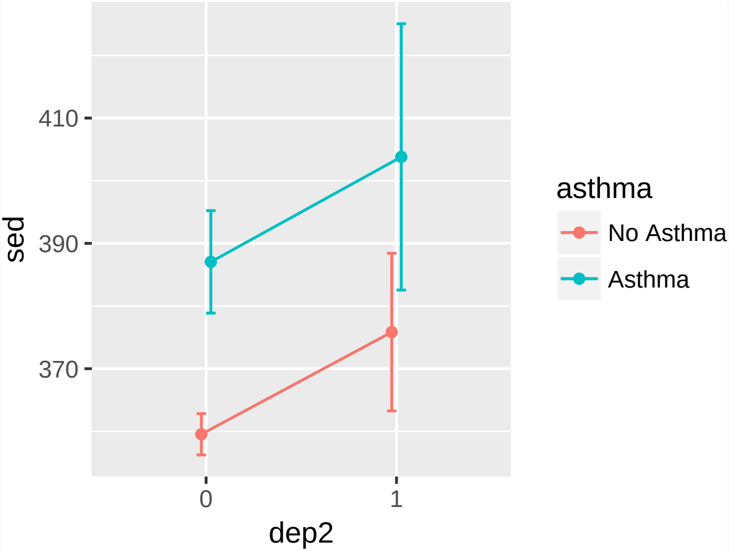


Line Plots

Good start, but let's add some features.

```r
pos = position_dodge(width = .1)
ggplot(summed_data, aes(x = dep2, y = sed,
                        group = asthma,
                        color = asthma)) +
  geom_line(position = pos) +
  geom_point(position = pos) +
  geom_errorbar(aes(ymin = sed - s_se,
                    ymax = sed + s_se),
                width = .1,
                position = pos)
```

Line Plots



That looks a bit better. From here, let's go on to color schemes to make the plots a bit better.

Color Schemes

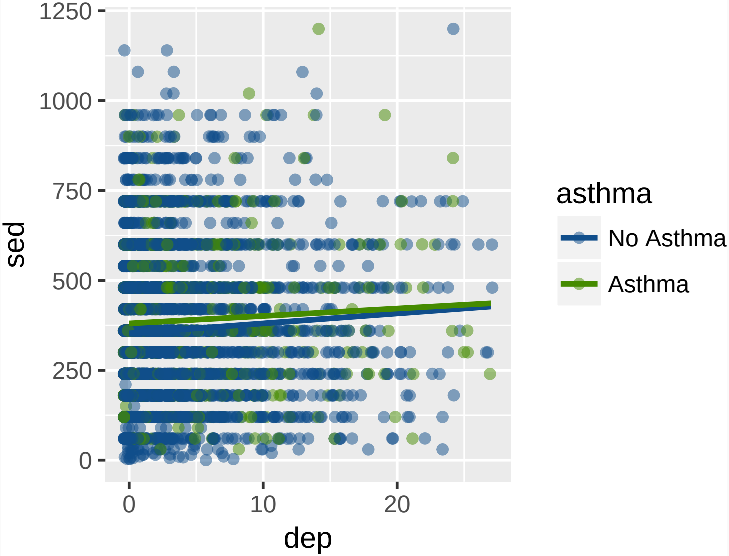
Color Schemes

We'll start by using the scatterplot we made above but we will change the colors a bit using `scale_color_manual()`.

```
ggplot(df, aes(x = dep, y = sed, group = asthma)) +
  geom_jitter(aes(color = asthma), alpha = .5) +
  geom_smooth(aes(color = asthma),
              method = "lm", se=FALSE) +
  scale_color_manual(values = c("dodgerblue4",
                                "chartreuse4"))
```

Color Schemes

We'll start by using the scatterplot we made above but we will change the colors a bit using `scale_color_manual()`.



Color Schemes

> *Don't get too lost in selecting colors but it can add a nice touch to any plot. The nuances of plot design can be invigorating but also time consuming to be smart about how long you spend using it.*

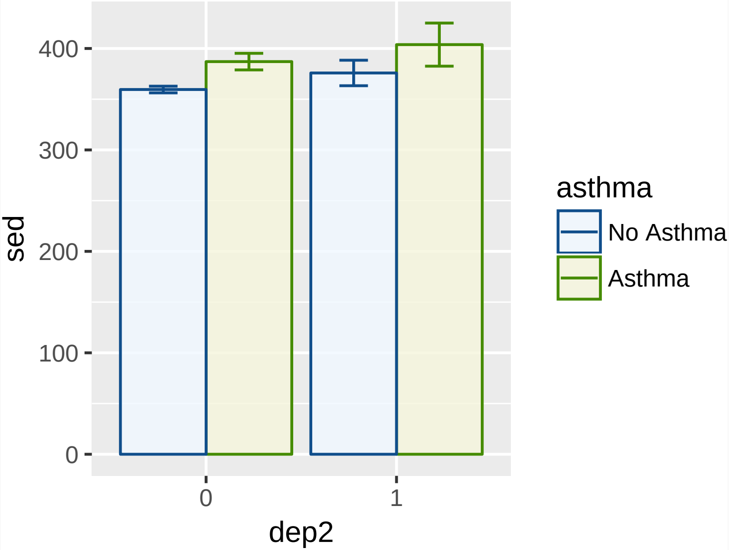
Next, let's adjust the bar plot. We will also add some colors here, but we will differentiate between "color" and "fill".

1. Fill fills in the object with color. This is useful for things that are more than simply a line or a dot.
2. Color colors the object. This outlines those items that can also be filled and colors lines and dots.

Color Schemes

```
p = position_dodge(width = .9)
ggplot(summed_data, aes(x = dep2, y = sed,
                        group = asthma)) +
  geom_bar(aes(fill = asthma, color = asthma),
           stat = "identity",
           position = p,
           alpha = .8) +
  geom_errorbar(aes(ymin = sed - s_se,
                    ymax = sed + s_se,
                    color = asthma),
                position = p,
                width = .3) +
  scale_color_manual(values = c("dodgerblue4",
                                "chartreuse4")) +
  scale_fill_manual(values = c("aliceblue", "beige"))
```

Color Schemes



Color Schemes

Just so you are aware:

- aliceblue is a lightblue
- beige is a light green
- dodgerblue4 is a dark blue
- chartreuse4 is a dark green

So the `fill` colors are light and the `color` colors are dark in this example. You, of course, can do whatever you want color-wise. I'm a fan of this style though so we will keep it for now.

These same functions can be used on the other plots as well. Feel free to give them a try. As for the book, we'll move on to the next section: Themes.

Themes

Themes

Using the plot we just made–the bar plot–we will show how theme options work. There are several built in themes that change many aspects of the plot (e.g., `theme_bw()`, `theme_classic()`, `theme_minimal()`). There are many more if you download the `ggthemes` package. Fairly simply you can create plots similar to those in newspapers and magazines.

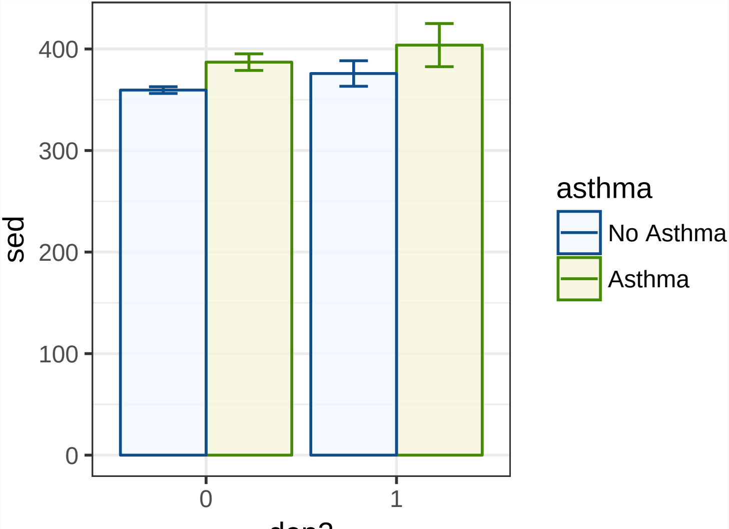
Themes

First, we are going to save the plot to simply show the different theming options.

```
p = position_dodge(width = .9)
p1 = ggplot(summed_data, aes(x = dep2, y = sed,
                             group = asthma)) +
  geom_bar(aes(fill = asthma, color = asthma),
           stat = "identity",
           position = p,
           alpha = .8) +
  geom_errorbar(aes(ymin = sed - s_se, ymax = sed + s_se,
                    color = asthma),
                position = p,
                width = .3) +
  scale_color_manual(values = c("dodgerblue4",
                                "chartreuse4")) +
  scale_fill_manual(values = c("aliceblue", "beige"))
```

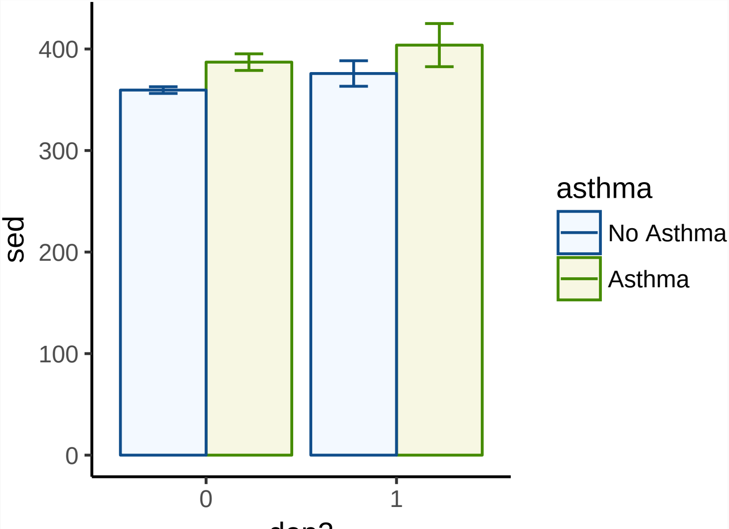
Theme Black and White

```
p1 +
  theme_bw()
```



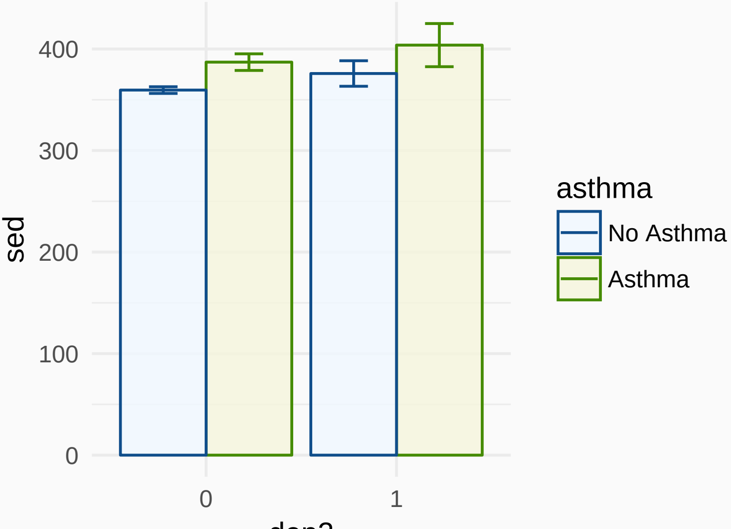
Theme Classic

```
p1 +
  theme_classic()
```



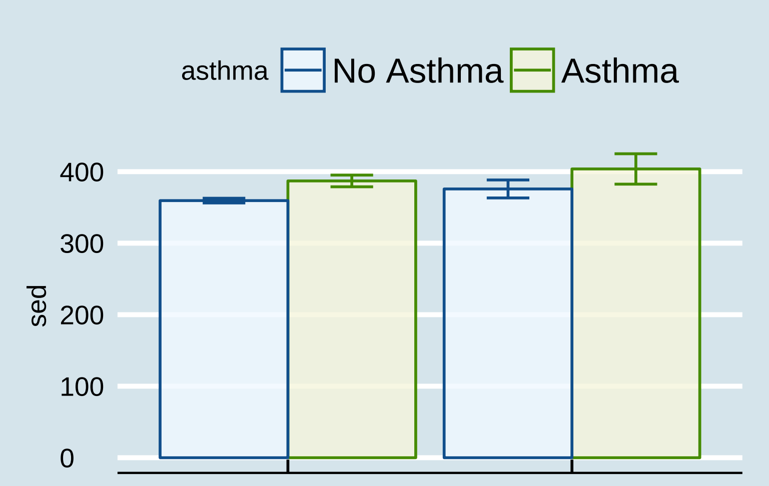
Theme Minimal

```
p1 +
  theme_minimal()
```



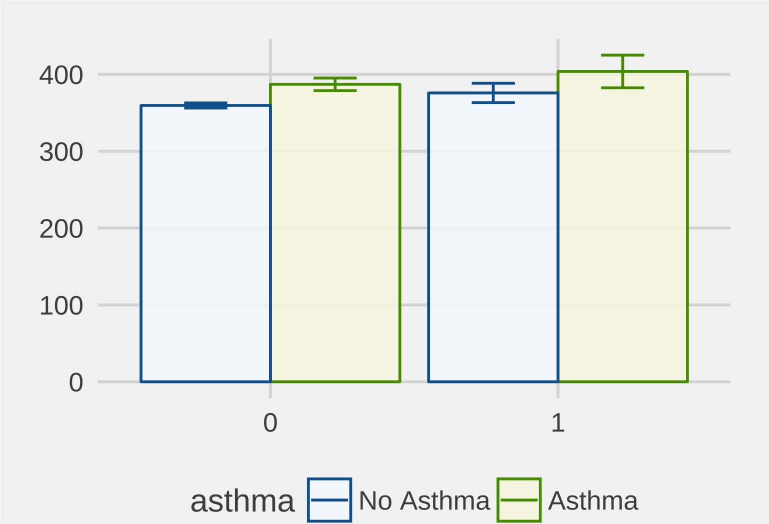
Theme Economist (from ggthemes)

```
library(ggthemes)
p1 +
  theme_economist()
```



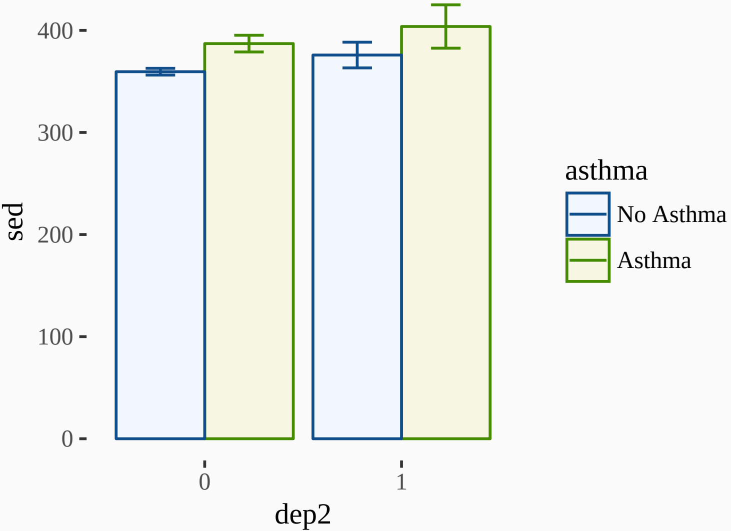
Theme FiveThirtyEight (from ggthemes)

```
p1 +
  theme_fivethirtyeight()
```



Theme Tufte (from ggthemes)

```
p1 +
  theme_tufte()
```

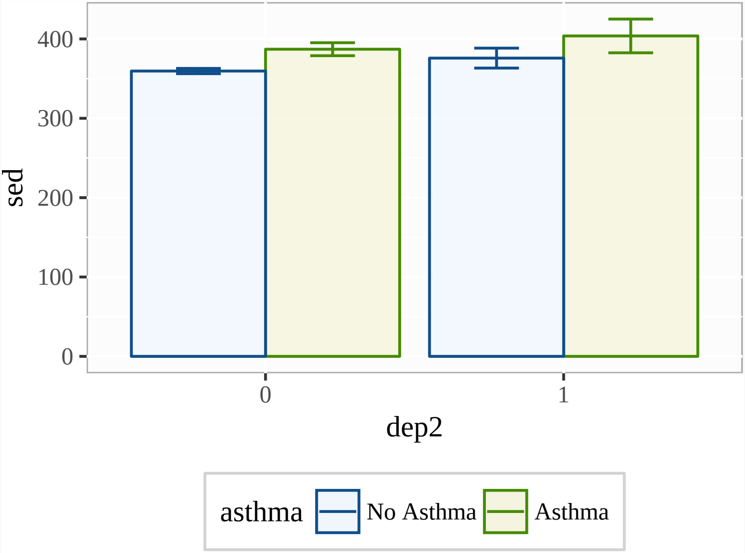


Your Own Theme

There are many more but you get the idea. In addition to the built in themes, you can use the `theme()` function and make your own adjustments. There are *many* options so we will just introduce the idea.

```r
p1 +
  theme(legend.position = "bottom",
        legend.background = element_rect(color = "lightgrey"),
        panel.background = element_rect(fill = "grey99",
                                        color = "grey70"),
        text = element_text(family = "Times"))
```

Your Own Theme



There are many more options but essentially if there is something you want to change, you probably can.

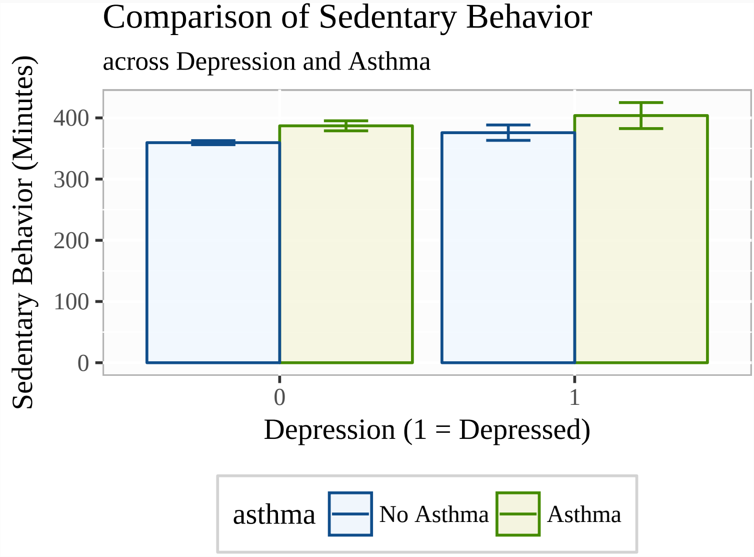
Labels and Titles

Labels and Titles

Using our last plot, we will also want to add good labels and/or titles.

```r
p1 +
  theme(legend.position = "bottom",
        legend.background = element_rect(color = "lightgrey"),
        panel.background = element_rect(fill = "grey99",
                                        color = "grey70"),
        text = element_text(family = "Times")) +
  labs(y = "Sedentary Behavior (Minutes)",
       x = "Depression (1 = Depressed)",
       title = "Comparison of Sedentary Behavior",
       subtitle = "across Depression and Asthma")
```

Labels and Titles



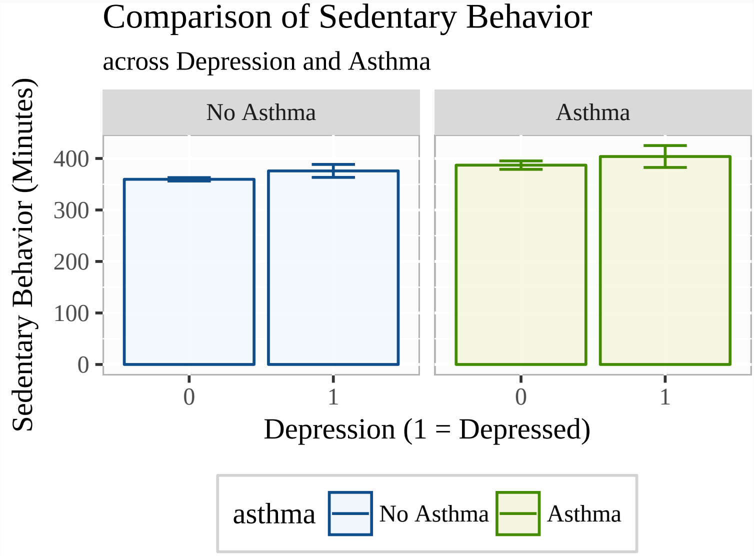
Facetting

Facetting

Facetting is very useful when trying to compare more than three variables at a time or you cannot use color or shading. It is often useful and beautiful. Facetting splits the data based on some grouping variable (e.g., asthma) to highlight differences in the relationship.

```r
p1 +
  theme(legend.position = "bottom",
        legend.background = element_rect(color = "lightgrey"),
        panel.background = element_rect(fill = "grey99",
                                        color = "grey70"),
        text = element_text(family = "Times")) +
  labs(y = "Sedentary Behavior (Minutes)",
       x = "Depression (1 = Depressed)",
       title = "Comparison of Sedentary Behavior",
       subtitle = "across Depression and Asthma") +
  facet_grid(~asthma)
```

Facetting



You can facet by more than one variable and it will create separate panels for each combination of the facetting variables.

Conclusions

Conclusions

This was a quick, but deeper, demonstration of plotting with `ggplot2`. There is so much more you can do.

However, in the end, exploring and communicating the data through plots is simply something you need to practice. With time, you can *a priori* picture the types of plots that will highlight things in your data, the ways you can adjust it, and how you need to manipulate your data to make it plot ready.

Be patient and have fun trying things. In my experience, almost anytime I think, “Can R do this?”, it can, so try to do cool stuff and you’ll probably find that you can.