Chapter 8. Axes

Having mastered the use of D3 scales, we now have the scatterplot shown in Figure 8-1.

Figure 8-1. Large, scaled scatterplot

Let's add horizontal and vertical axes, so we can do away with the horrible red numbers cluttering up our chart.

Introducing Axes

Much like its scales, D3's *axes* are actually *functions* whose parameters you define. Unlike scales, when an axis function is called, it doesn't return a value, but generates the visual elements of the axis, including lines, labels, and ticks.

Note that the axis functions are SVG-specific, as they generate SVG elements. Also, axes are intended for use with quantitative scales (as opposed to ordinal ones).

Setting Up an Axis

Use `d3.svg.axis()` to create a generic axis function:

```
var xAxis = d3.svg.axis();
```

At a minimum, each axis also needs to be told on what *scale* to operate. Here we'll pass in the `xScale` from the scatterplot code:

```
xAxis.scale(xScale);
```

We can also specify where the labels should appear relative to the axis itself. The default is `bottom`, meaning the labels will appear below the axis line. (Although this is the default, it can't hurt to specify it explicitly.) Possible orientations for horizontal axes are `top` and `bottom`. For vertical axes, use `left` and `right`:

```
xAxis.orient("bottom");
```

Of course, we can be more concise and string all this together into one line:

```
var xAxis = d3.svg.axis()
                  .scale(xScale)
                  .orient("bottom");
```

Finally, to actually generate the axis and insert all those little lines and labels into our SVG, we must *call* the `xAxis` function. This is similar to the scale functions, which we first configured by setting parameters, and then later *called*, to put them into action.

I'll put this code at the end of our script, so the axis is generated after the other elements in the SVG, and therefore appears "on top":

```
svg.append("g")
    .call(xAxis);
```

This is where things get a little funky. You might be wondering why this looks so different from our friendly scale functions. Here's why: because an *axis* function actually draws something to the screen (by appending SVG elements to the DOM), we need to specify *where* in the DOM it should place those new elements. This is in contrast to scale functions like `xScale()`, for example, which calculate a value and return those values, typically for use by yet another function, without impacting the DOM at all.

So what we're doing with the preceding code is to first reference `svg`, the SVG image in the DOM. Then, we `append()` a new `g` element to the end of the SVG. In SVG land, a `g` element is a *group* element. Group elements are invisible, unlike `line`, `rect`, and `circle`, and they have no visual presence themselves.

Yet they help us in two ways: first, `g` elements can be used to contain (or "group") other elements, which keeps our code nice and tidy. Second, we can apply *transformations* to `g` elements, which affects how visual elements within that group (such as `lines`, `rects`, and `circles`) are rendered. We'll get to transformations in just a minute.

So we've created a new `g`, and then finally, the function `call()` is called on our new `g`. So what is `call()`, and who is it calling?

D3's `call()` function takes the incoming *selection*, as received from the prior link in the chain, and hands that selection off to any *function*. In this case, the selection is our new `g` group element. Although the `g` isn't strictly necessary, we are using it because the axis function is about to generate lots of crazy lines and numbers, and it's nice to contain all those elements within a single group object. `call()` hands off `g` to the `xAxis` function, so our axis is generated *within* `g`.

If we were messy people who loved messy code, we could also rewrite the preceding snippet as this exact equivalent:

```
svg.append("g")
    .call(d3.svg.axis()
    .scale(xScale)
    .orient("bottom"));
```

See, you could cram the whole axis function within `call()`, but it's usually easier on our brains to define functions first, then call them later.

In any case, Figure 8-2 shows what that looks like. See code example *01_axes.html*.

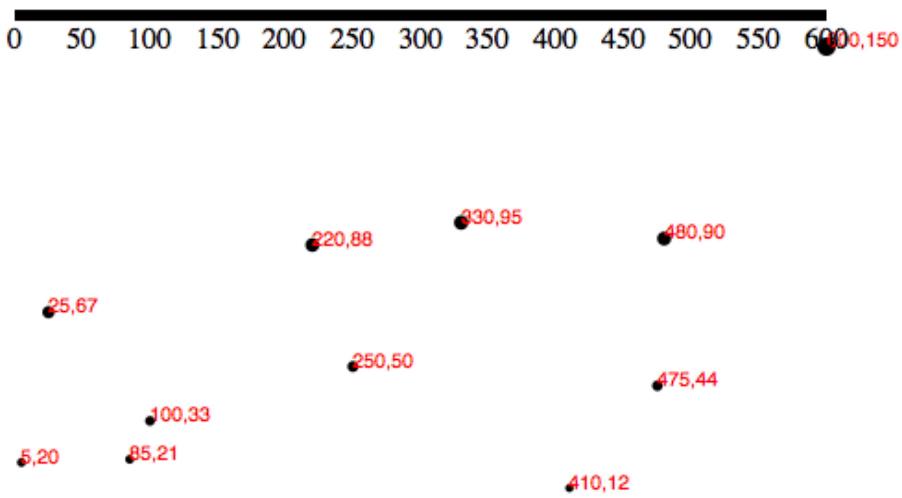
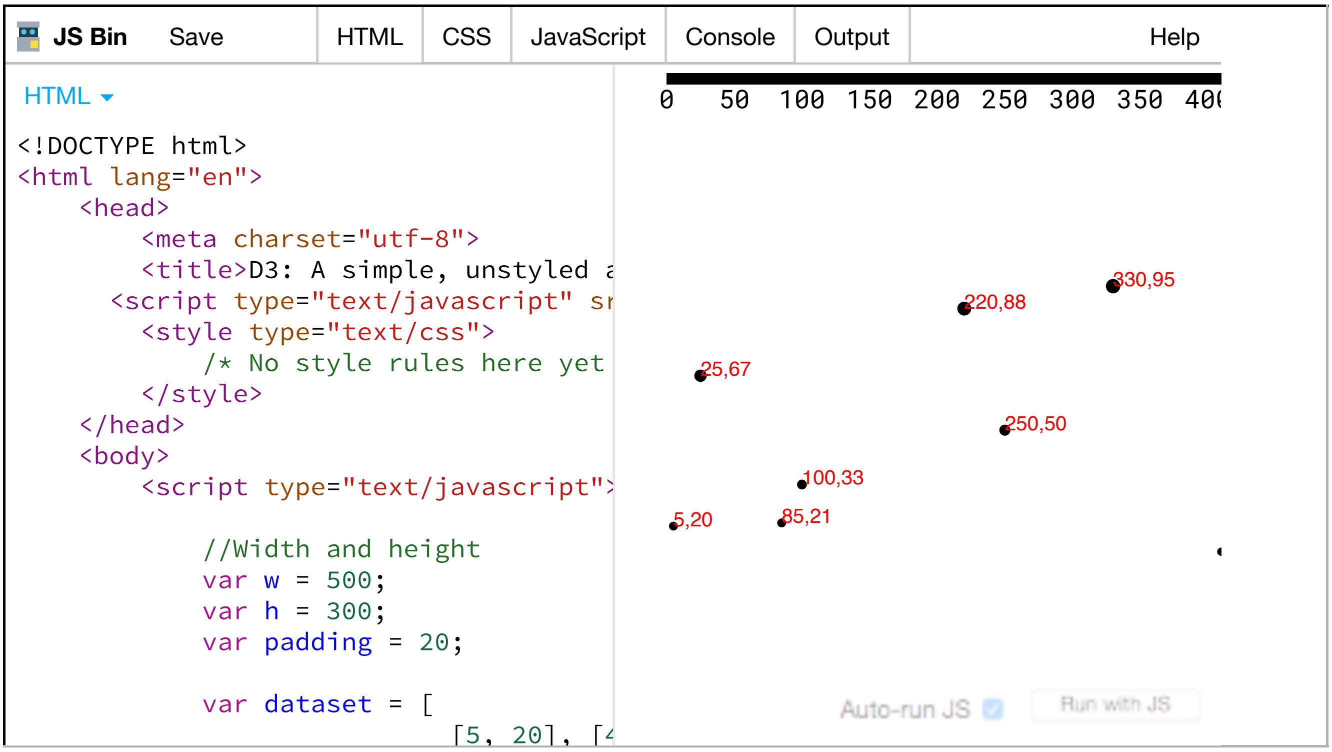


Figure 8-2. Simple, but ugly axis

Try It Now!

Try editing the `dataset` values below at left, and watch the scale adjust in the output at right.

[Open in new window]



Cleaning It Up

Technically, that is an axis, but it’s neither pretty nor useful. To clean it up, let’s first assign a class of `axis` to the new `g` element, so we can target it with CSS:

```
svg.append("g")
    .attr("class", "axis") //Assign "axis" class
    .call(xAxis);
```

Then, we introduce our first CSS styles, up in the `<head>` of our page:

```
.axis path,
.axis line {
    fill: none;
    stroke: black;
    shape-rendering: crispEdges;
}

.axis text {
    font-family: sans-serif;
    font-size: 11px;
}
```

See how useful it is to group all the axis elements within one `g` group? Now we can very easily apply styles to anything within the group using the simple CSS selector `.axis`. The axes themselves are made up of `path`, `line`, and `text` elements, so those are the three elements that we target in our CSS. The `path`s and `line`s can be styled with the same rules, and `text` gets its own rules around font and font size.

You might notice that when we use CSS rules to style SVG elements, only SVG attribute names—not regular CSS properties—should be used. This is confusing, because many properties share the same names in both CSS and SVG, but some do not. For example, in regular CSS, to set the color of some text, you would use the `color` property, as in:

```
p {
    color: olive;
}
```

That will set the text color of all `p` paragraphs to be `olive`. But try to apply this property to an SVG element, as with:

```
text {
    color: olive;
}
```

and it will have no effect because `color` is not a property recognized by SVG. Instead, you must use SVG's equivalent, `fill`:

```
text {
    fill: olive;
}
```

If you ever find yourself trying to style SVG elements, but for some reason the stupid CSS code just isn't working, I suggest you take a deep breath, pause, and then review your *property names* very closely to ensure you're using SVG names, not CSS ones. (You can reference the complete SVG attribute list on the MDN site.)

The `shape-rendering` property is another weird SVG attribute you should know. We use it here to make sure our axis and its tick mark lines are pixel-perfect. No blurry axes for us!

The chart looks like Figure 8-3 after our CSS clean-up.

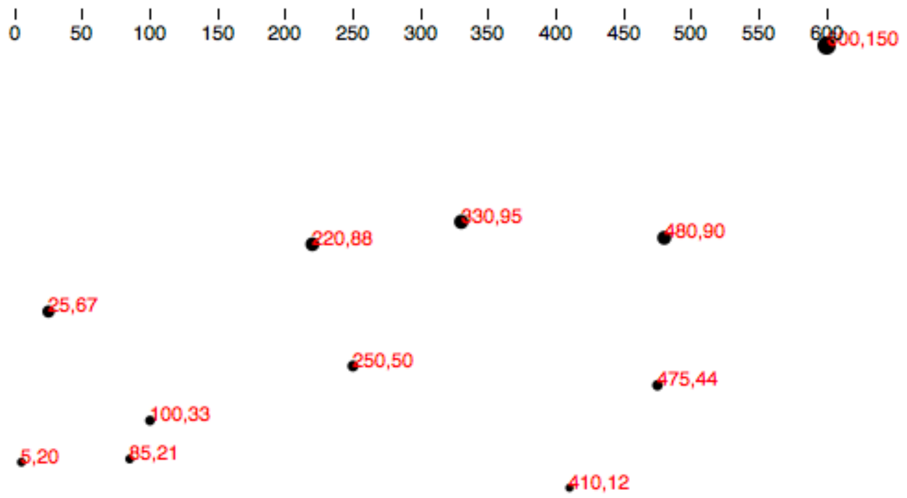


Figure 8-3. Cleaner axis

That's better, but the top horizontal line of the axis is cut off, and the axis itself should be down at the base of the chart anyway. Here's where SVG *transformations* come in. By adding one line of code, we can `transform` the entire axis group, pushing it to the bottom:

```
svg.append("g")
    .attr("class", "axis")
    .attr("transform", "translate(0," + (h - padding) + ")")
    .call(xAxis);
```

Note that we use `attr()` to apply `transform` as an attribute of `g`. SVG transforms are quite powerful, and can accept several different kinds of transform definitions, including scales and rotations. But we are keeping it simple here with only a *translation* transform, which simply pushes the whole `g` group over and down by some amount.

Translation transforms are specified with the easy syntax of `translate(x,y)`, where `x` and `y` are, obviously, the number of horizontal and vertical pixels by which to translate the element. So, in the end, we would like our `g` to look like this in the DOM:

```
<g class="axis" transform="translate(0,280)">
```

As you can see, the `g.axis` isn't moved horizontally at all, but it is pushed 280 pixels down, conveniently to the base of our chart. We specify as much in this line of code:

```
    .attr("transform", "translate(0," + (h - padding) + ")")
```

Note the use of `(h - padding)`, so the group's top edge is set to `h`, the height of the entire image, minus the `padding` value we created earlier. `(h - padding)` is calculated to be `280`, and then connected to the rest of the string, so the final transform property value is `translate(0,280)`.

The result in Figure 8-4 is much better! Check out the code so far in *02_axes_bottom.html*.

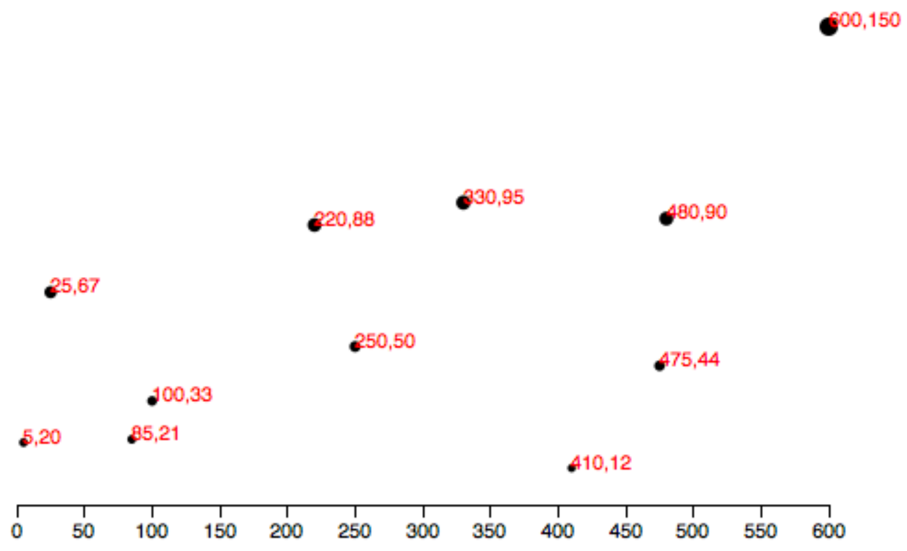


Figure 8-4. Nice, clean axis

Check for Ticks

Some ticks spread disease, but D3's ticks communicate information. Yet more ticks are not necessarily better, and at a certain point, they begin to clutter your chart. You'll notice that we never specified how many ticks to include on the axis, nor at what intervals they should appear. Without clear instruction, D3 has automagically examined our scale `xScale` and made informed judgments about how many ticks to include, and at what intervals (every 50, in this case).

As you would expect, you can customize all aspects of your axes, starting with the rough number of ticks, using `ticks()`:

```
var xAxis = d3.svg.axis()
                  .scale(xScale)
                  .orient("bottom")
                  .ticks(5);  //Set rough # of ticks
```

See *03_axes_clean.html* for that code.

You'll notice in Figure 8-5 that, although we specified only five ticks, D3 has made an executive decision and ordered up a total of seven. That's because D3 has got your back, and figured out that including only *five* ticks would require slicing the input domain into less-than-gorgeous values—in this case, 0, 150, 300, 450, and 600. D3 inteprets the `ticks()` value as merely a suggestion and will override your suggestion with what it determines to be the most clean and human-readable values—in this case, intervals of 100—even when that requires including slightly more or fewer ticks than you requested. This is actually a totally brilliant feature that increases the scalability of your design; as the dataset changes and the input domain expands or contracts (bigger numbers or smaller numbers), D3 ensures that the tick labels remain easy to read.

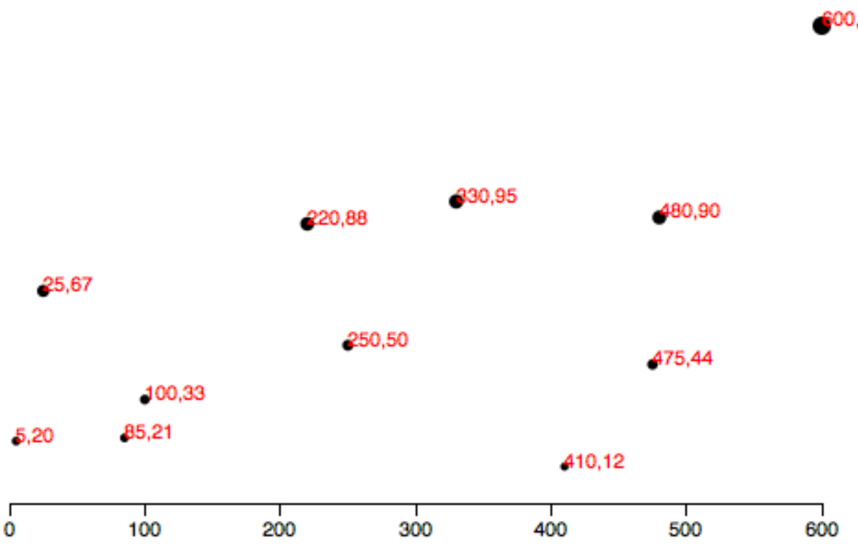


Figure 8-5. Fewer ticks

Y Not?

Time to label the vertical axis! By copying and tweaking the code we already wrote for the `xAxis`, we add this near the top of of our code:

```
//Define Y axis
var yAxis = d3.svg.axis()
                  .scale(yScale)
                  .orient("left")
                  .ticks(5);
```

and this, near the bottom:

```
//Create Y axis
svg.append("g")
    .attr("class", "axis")
    .attr("transform", "translate(" + padding + ",0)")
    .call(yAxis);
```

Note in Figure 8-6 that the labels will be oriented `left` and that the `yAxis` group `g` is translated to the right by the amount `padding`.

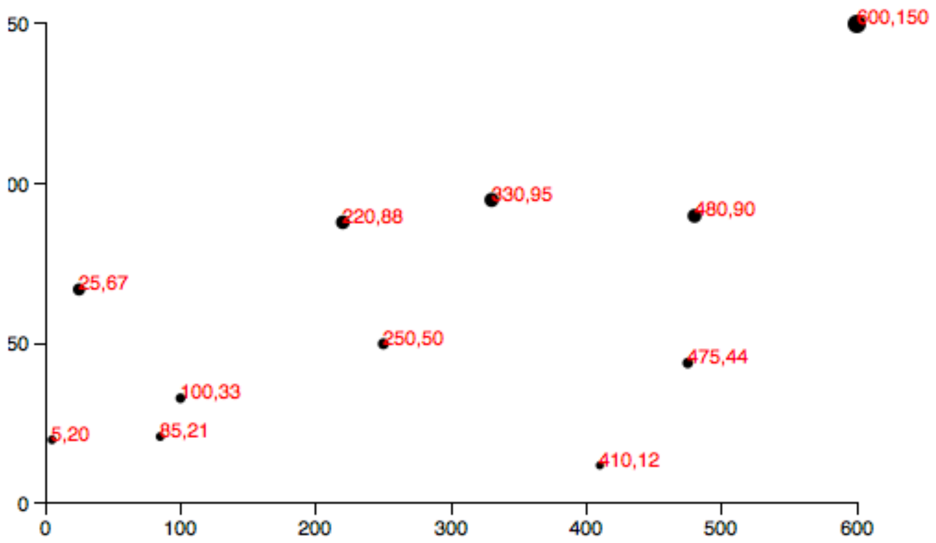


Figure 8-6. Initial y-axis

This is starting to look like a real chart! But the `yAxis` labels are getting cut off. To give them more room on the left side, I'll bump up the value of `padding` from 20 to 30:

```
var padding = 30;
```

Of course, you could also introduce separate `padding` variables for each axis, say `xPadding` and `yPadding`, for more control over the layout.

See the updated code in *04_axes_y.html*. It looks like Figure 8-7.

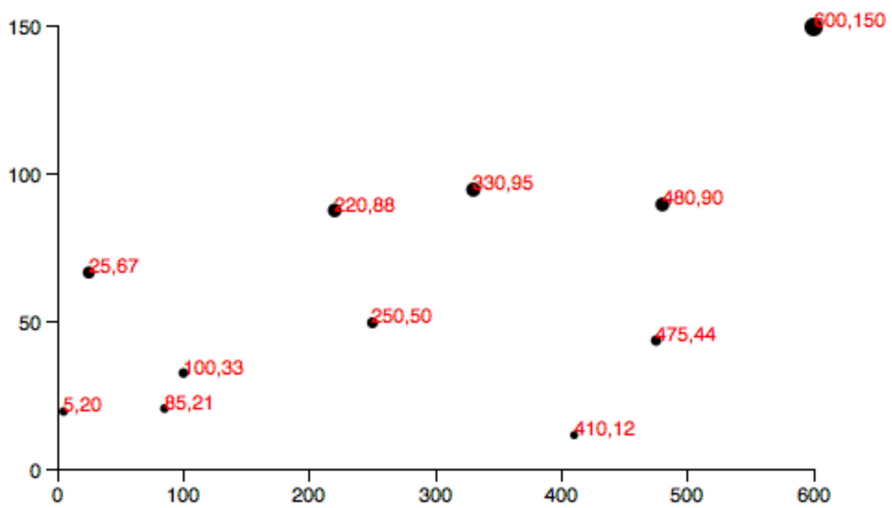
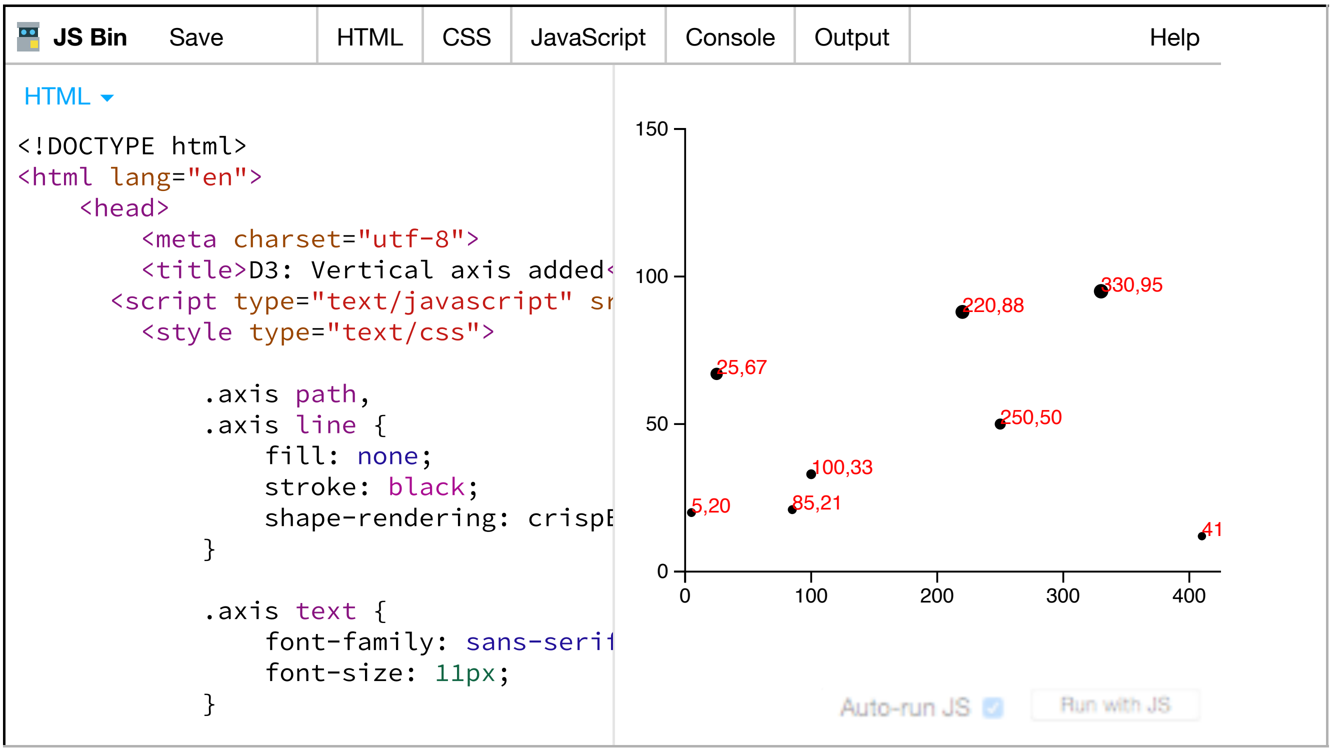


Figure 8-7. Scatterplot with y-axis

Try It Now!

Try editing the `dataset` values below at left, and watch both the x- and y- scales update at right

[Open in new window]()



Final Touches

I appreciate that so far you have been very quiet and polite, and not at all confrontational. Yet I still feel as though I have to win you over. So to prove to you that our new axes are dynamic and scalable, I'd like to switch from using a static dataset to using randomized numbers:

```
//Dynamic, random dataset
var dataset = [];
var numDataPoints = 50;
var xRange = Math.random() * 1000;
var yRange = Math.random() * 1000;
for (var i = 0; i < numDataPoints; i++) {
    var newNumber1 = Math.floor(Math.random() * xRange);
    var newNumber2 = Math.floor(Math.random() * yRange);
    dataset.push([newNumber1, newNumber2]);
}
```

This code initializes an empty array, then loops through 50 times, chooses two random numbers each time, and adds ("pushes") that pair of values to the `dataset` array (see [Figure 8-8](#)).

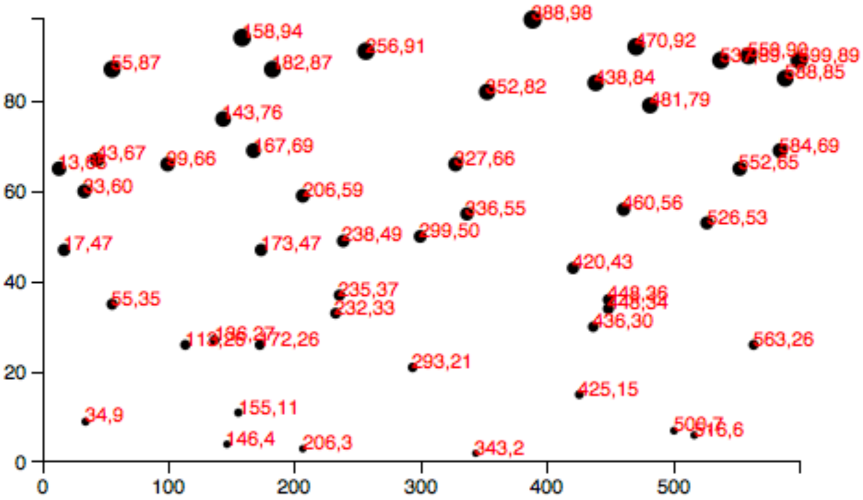


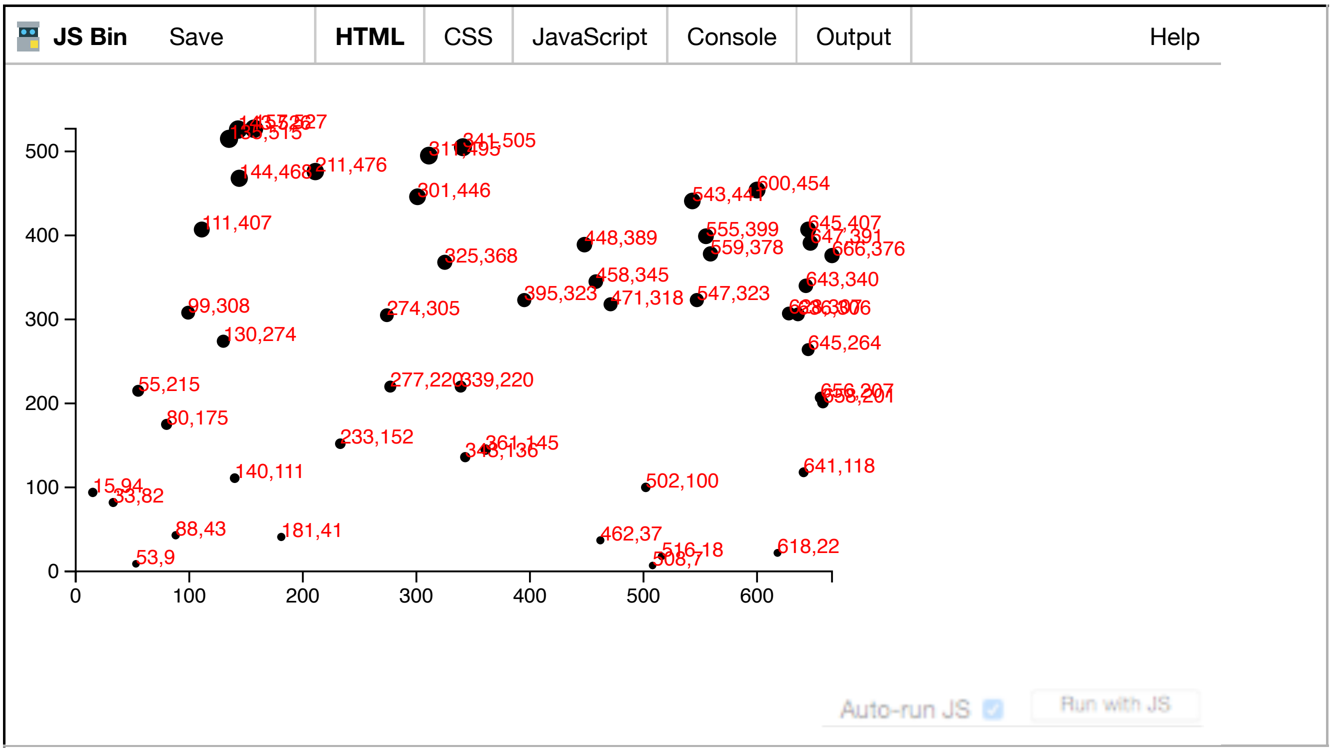
Figure 8-8. Scatterplot with random data

Try out that randomized dataset code in *05_axes_random.html*. Each time you reload the page, you'll get different data values. Notice how both axes scale to fit the new domains, and ticks and label values are chosen accordingly.

Try It Now!

Regenerate the scatterplot below by hovering over the graph and then hitting the "Run with JS" button, and watch the scales on the axes dynamically update to fit the randomly generated data points.

[Open in new window](#)



Having made my point, I think we can finally cut those horrible, red labels, by commenting out the relevant lines of code.

The result is shown in Figure 8-9. Our final scatterplot code lives in *06_axes_no_labels.html*.

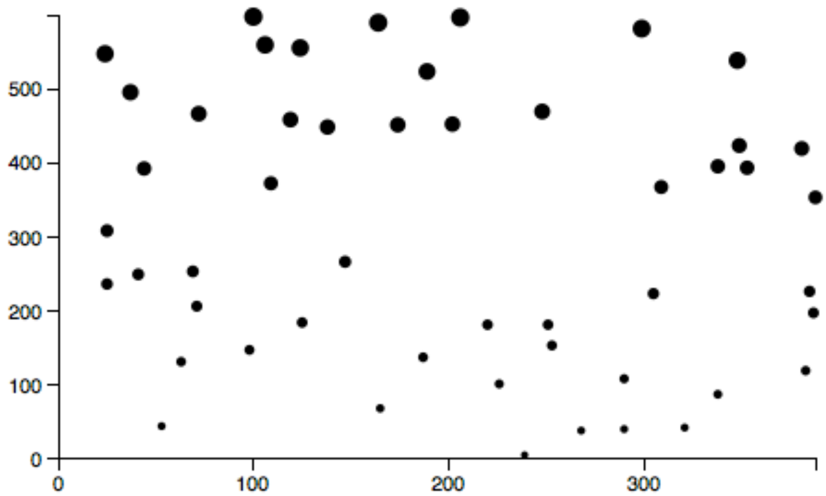


Figure 8-9. Scatterplot with random data and no red labels

Formatting Tick Labels

One last thing: so far, we've been working with integers—whole numbers—which are nice and easy. But data is often messier, and in those cases, you might want more control over how the axis labels are formatted. Enter `tickFormat()`, which enables you to specify how your numbers should be formatted. For example, you might want to include three places after the decimal point, or display values as percentages, or both.

To use `tickFormat()`, first define a new number-formatting function. This one, for example, says to treat values as percentages with one decimal point precision. That is, if you give this function the number `0.23`, it will return the string `23.0%`. (See [the reference entry for `d3.format()`] for more options.)

```
var formatAsPercentage = d3.format(".1%");
```

Then, tell your axis to use that formatting function for its ticks, for example:

```
xAxis.tickFormat(formatAsPercentage);
```

I find it easiest to test these formatting functions out in the JavaScript console. For example, just open any page that loads D3, such as *06_axes_no_labels.html*, and type your format rule into the console. Then test it by feeding it a value, as you would with any other function.

You can see in Figure 8-10 that a data value of `0.54321` is converted to `54.3%` for display purposes—perfect!

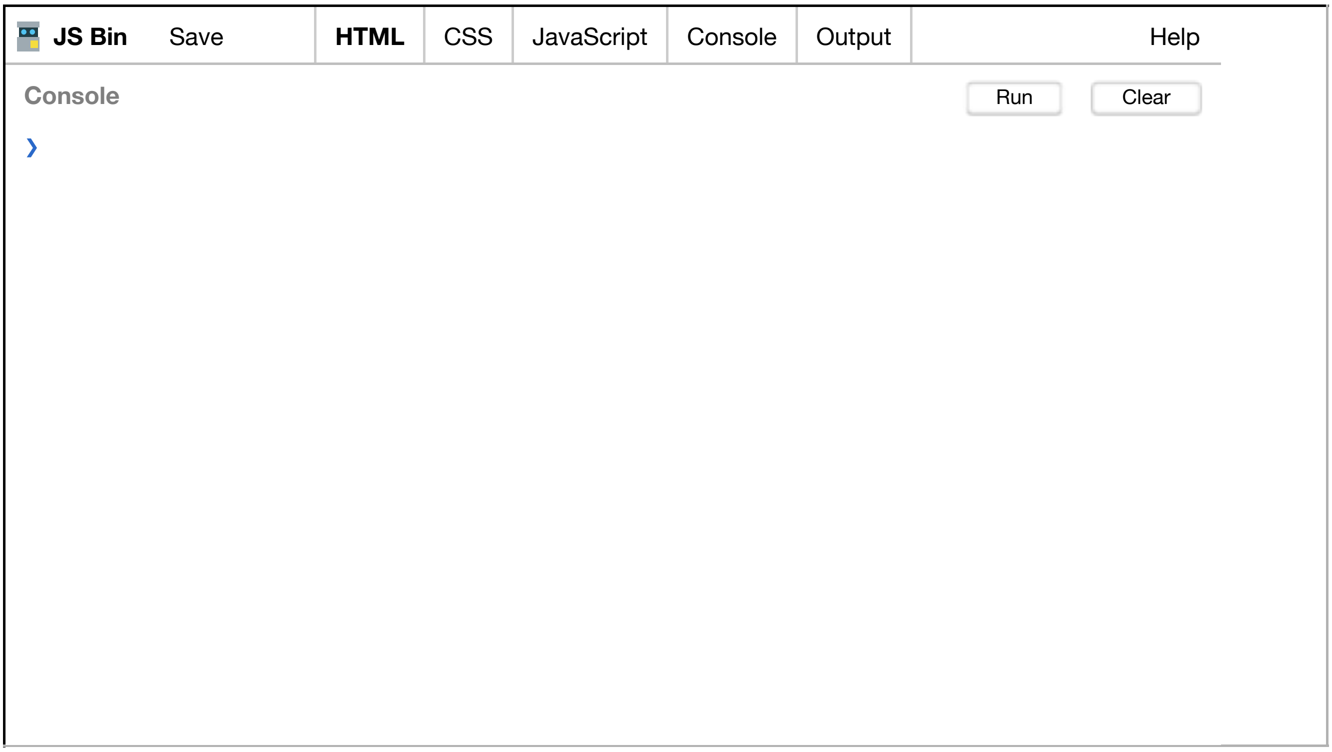
```
> var formatAsPercentage = d3.format(".1%");
  undefined
> formatAsPercentage(0.54321)
  "54.3%"
>
```

Figure 8-10. Testing format() in the console

Try It Now!

Try entering the following `formatAsPercentage` statements in the console below to see the results:

- `formatAsPercentage(.365);`
- `formatAsPercentage(1.2);`
- `formatAsPercentage(-.5);`



You can play with that code in *07_axes_format.html*. Obviously, a percentage format doesn't make sense with our scatterplot's current dataset, but as an exercise, you could try tweaking how the random numbers are generated, to make more appropriate, non-whole number values, or just experiment with the format function itself.