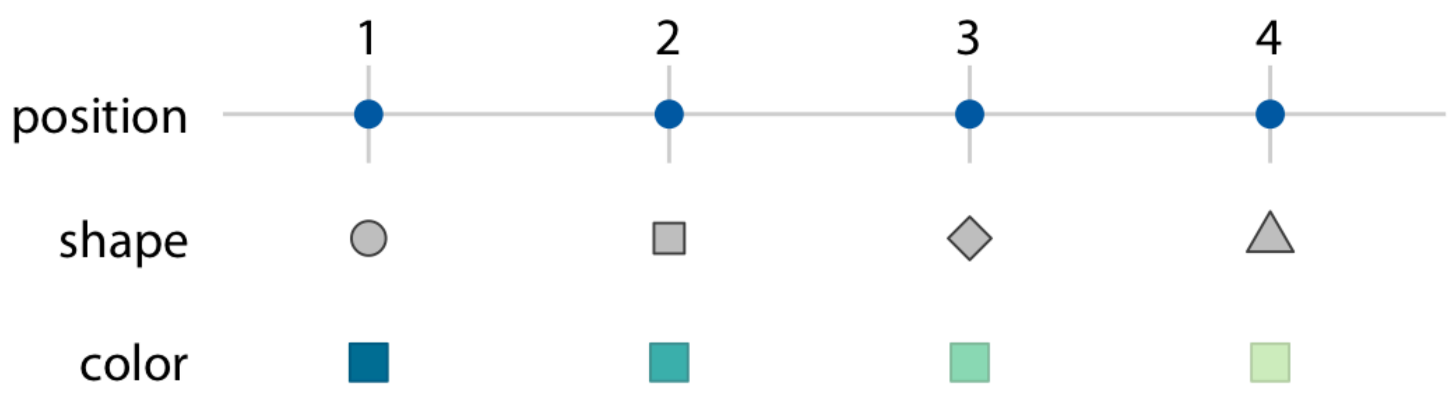
S. Rinzivillo – rinzivillo@isti.cnr.it

DATA VISUALIZATION AND VISUAL ANALYTICS

SCALES FUNCTION

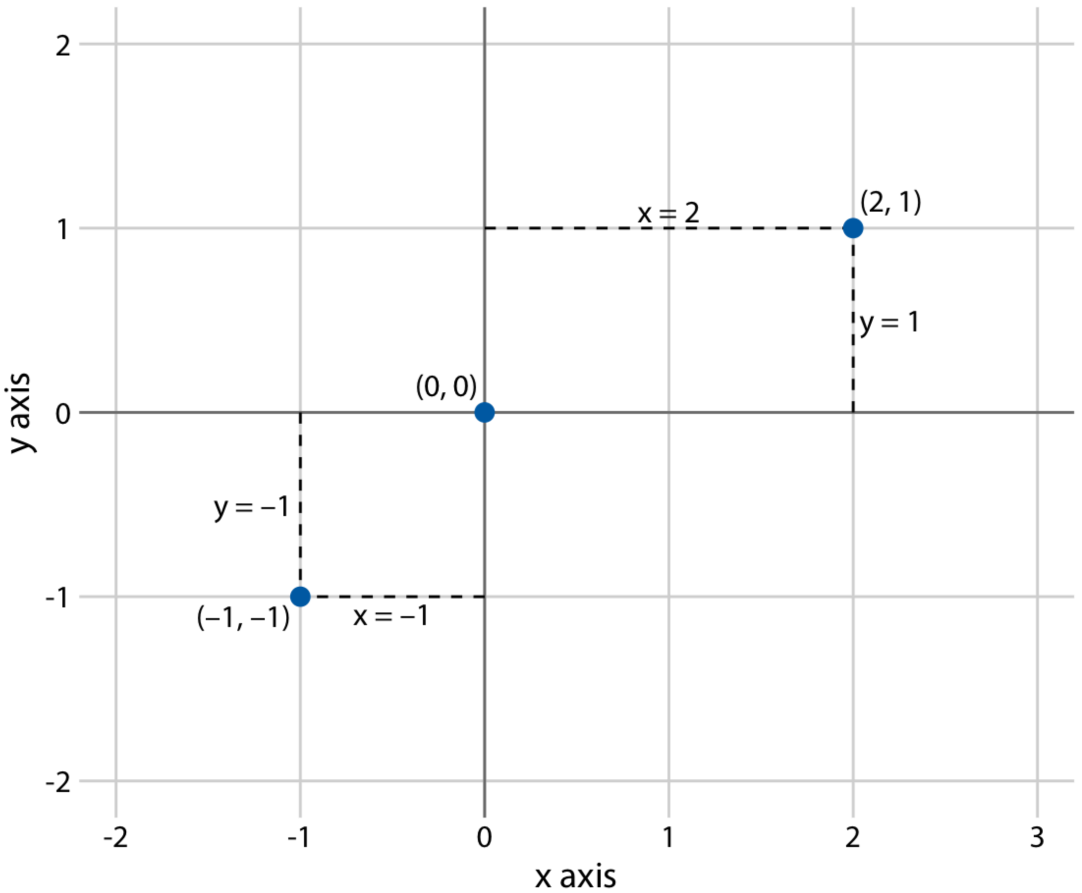
Map data to VV

- We specify a scaling function to map data values to the visual representation
- A scale is a unique mapping between data and visual representation
- Scales are **functions** that map from an input domain to an output range

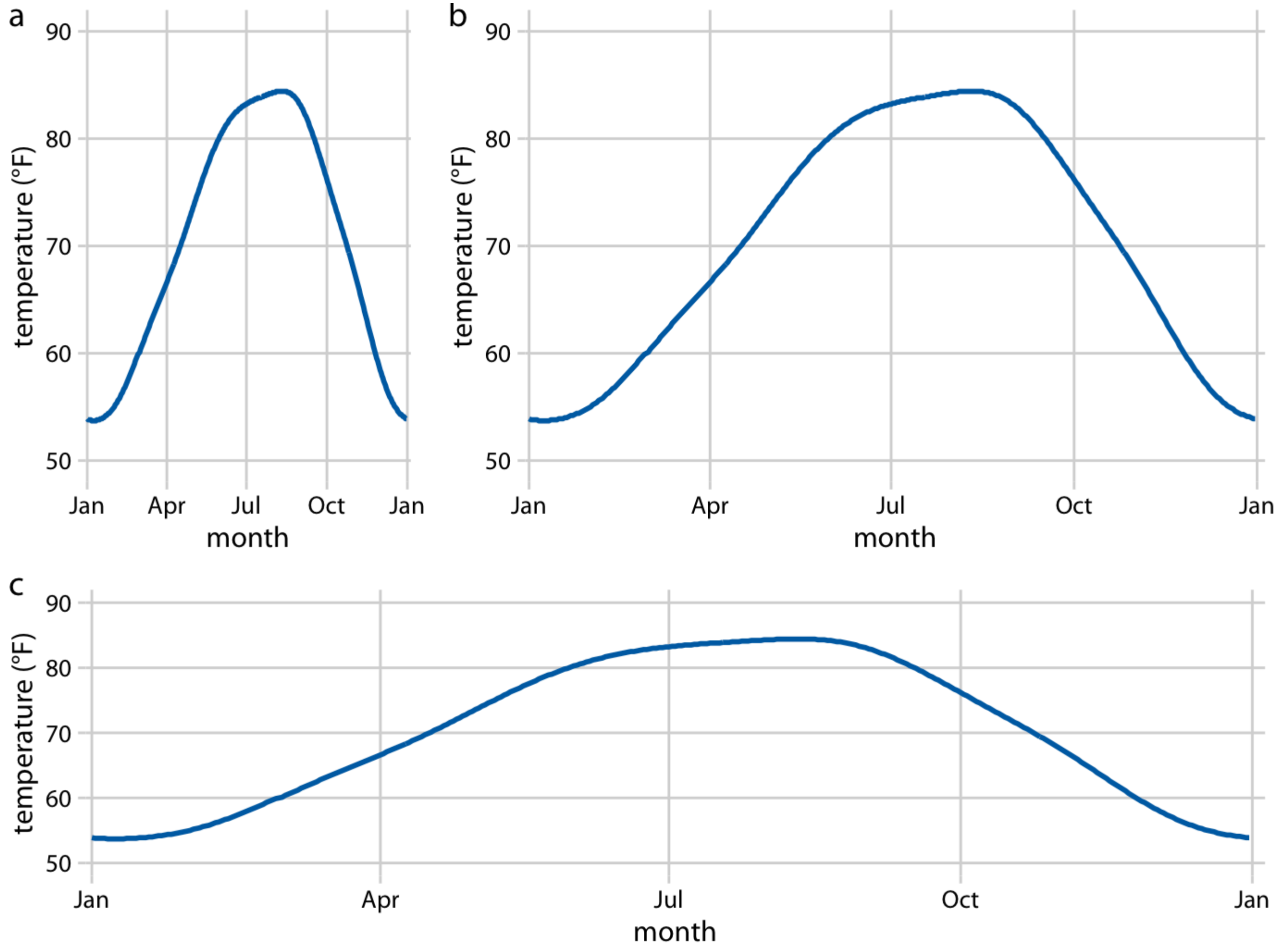


Positional scales: axis

- Axis are at the base of many scientific plots
- Cartesian coordinate systems are composed of two orthogonal axis
- Values are positioned proportionally on the axes



Cartesian diagram with different scales



Cartesian diagram with different scales

CHART THAT TRUMP SIGNED
AND SENT TO HIS FOLLOWERS

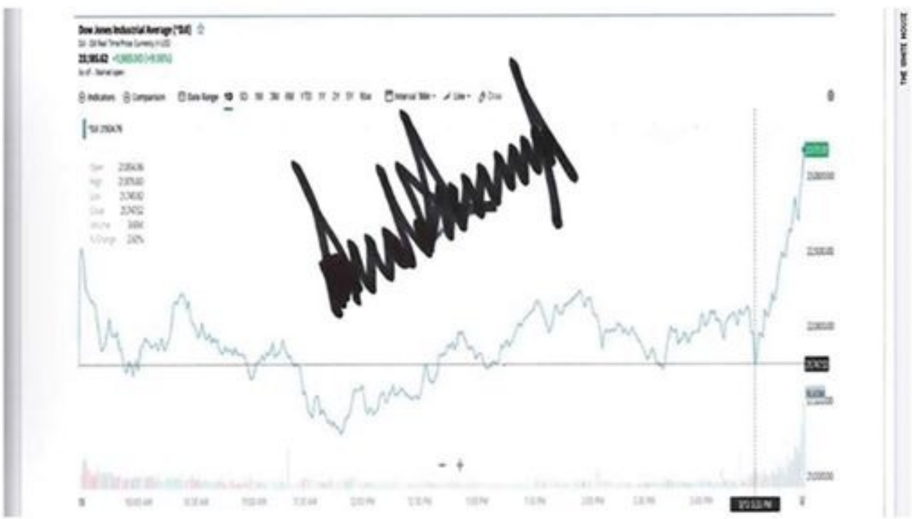
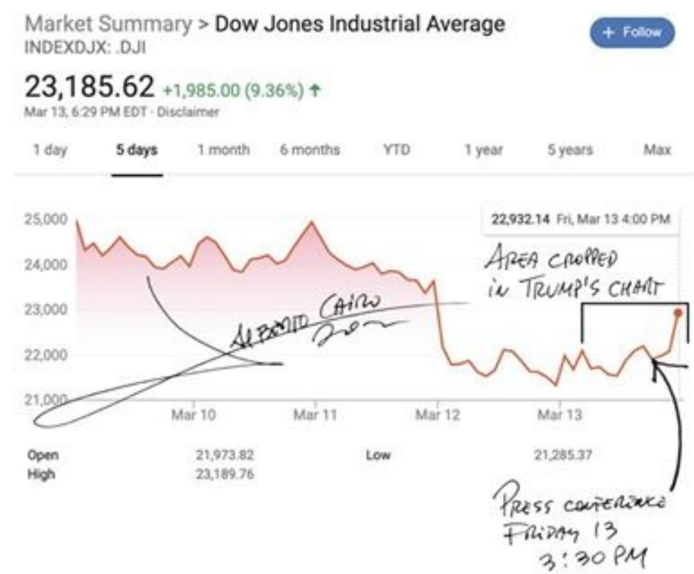
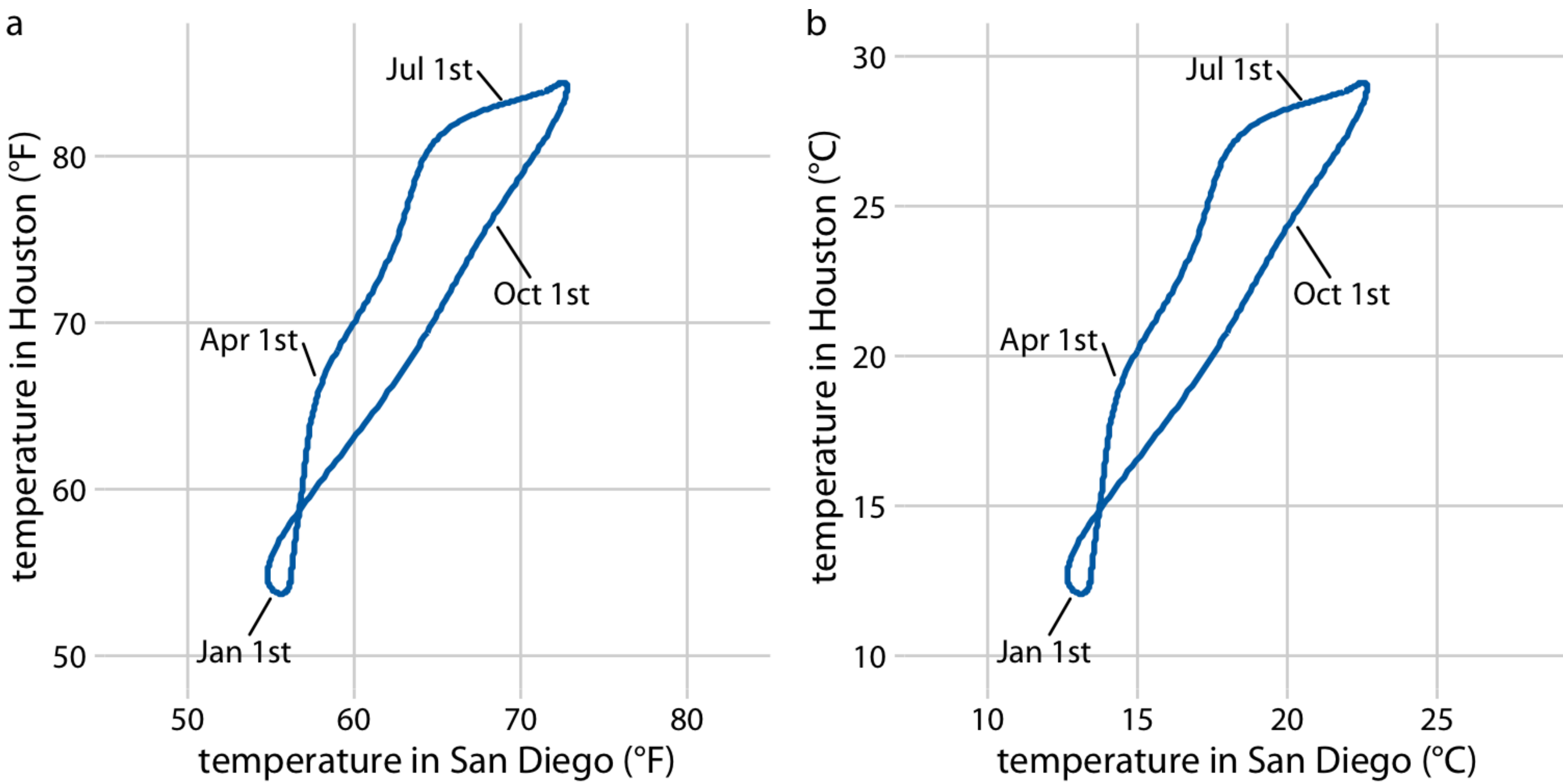


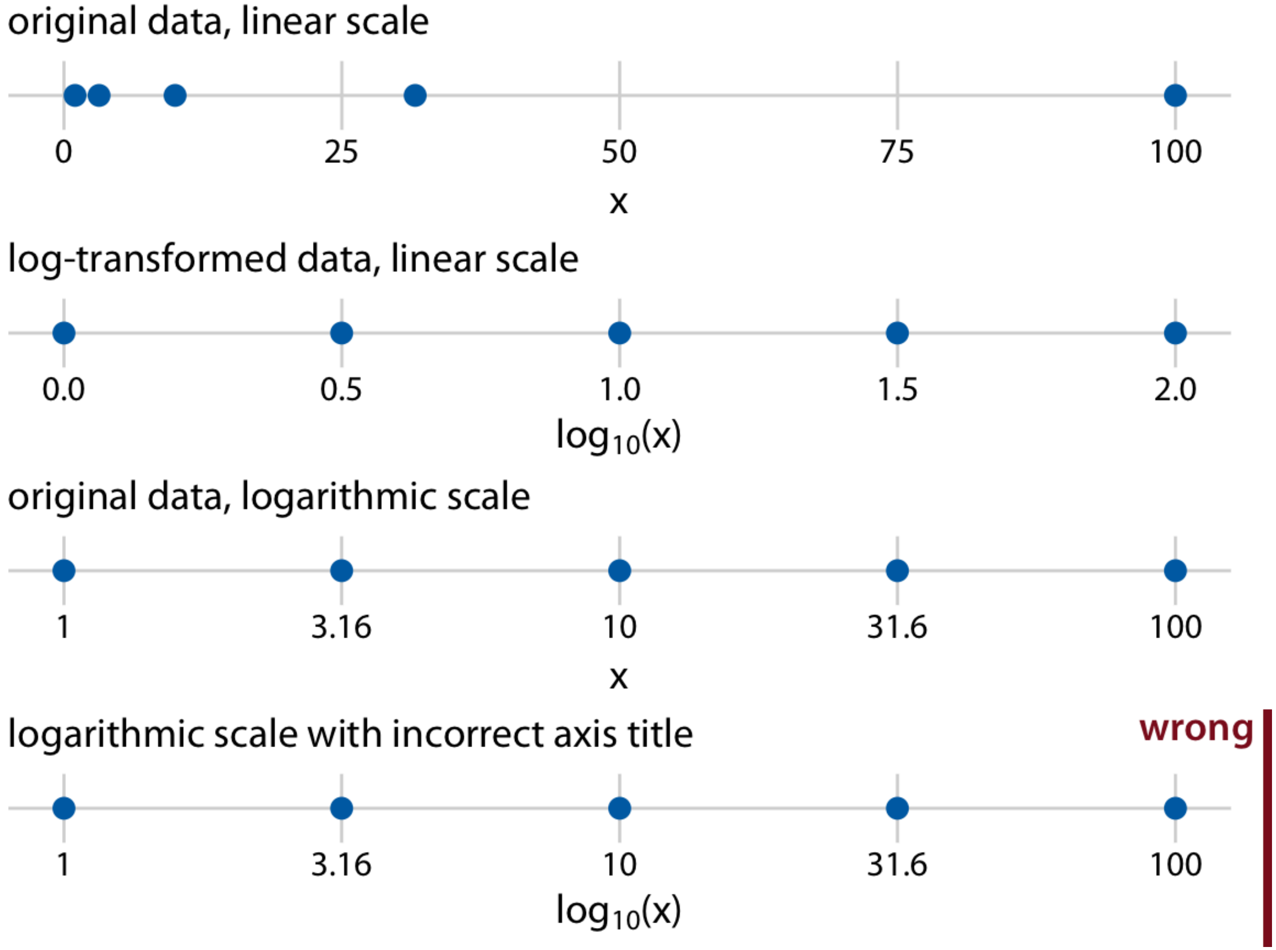
CHART THAT I SIGNED
AND SENT TO MY FOLLOWERS



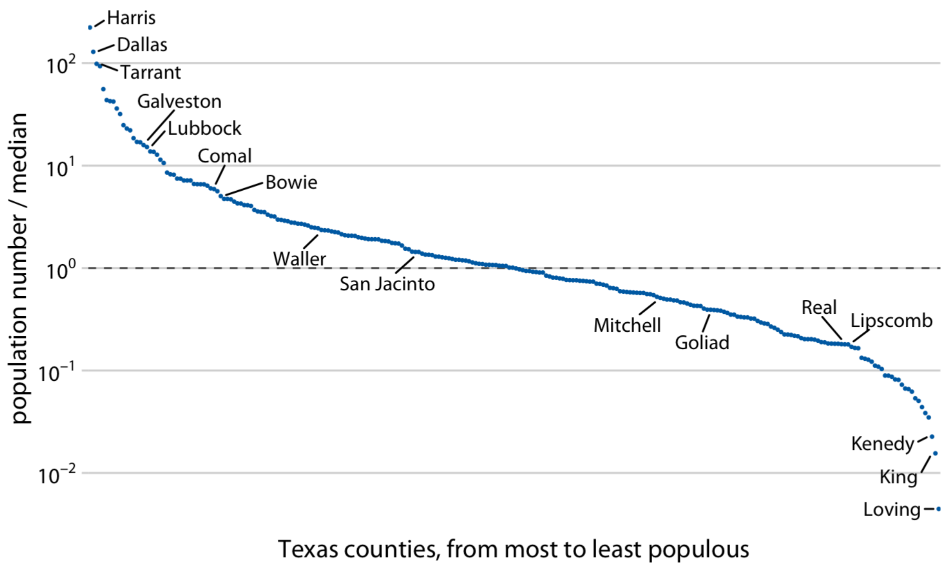
Cartesian axes with same scale

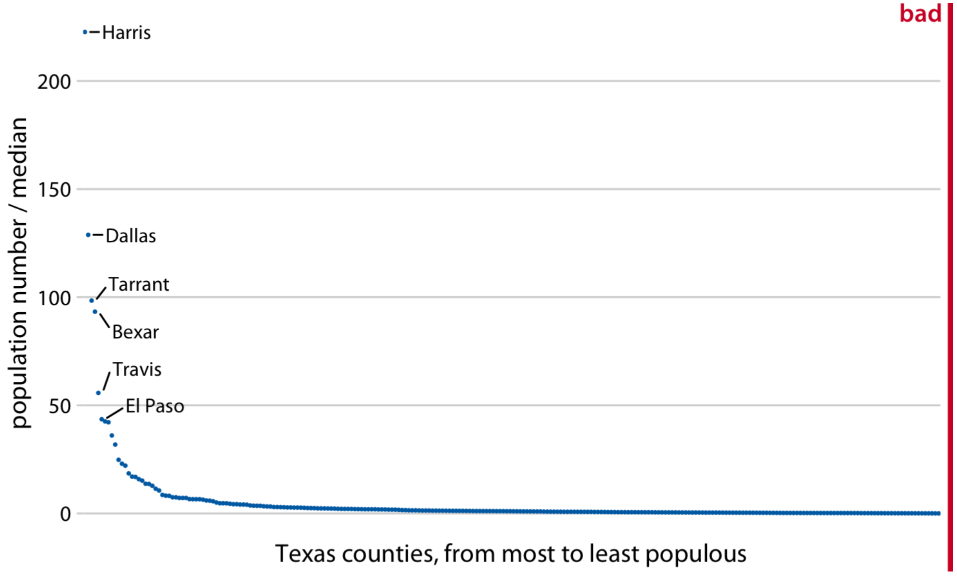


Non linear axes

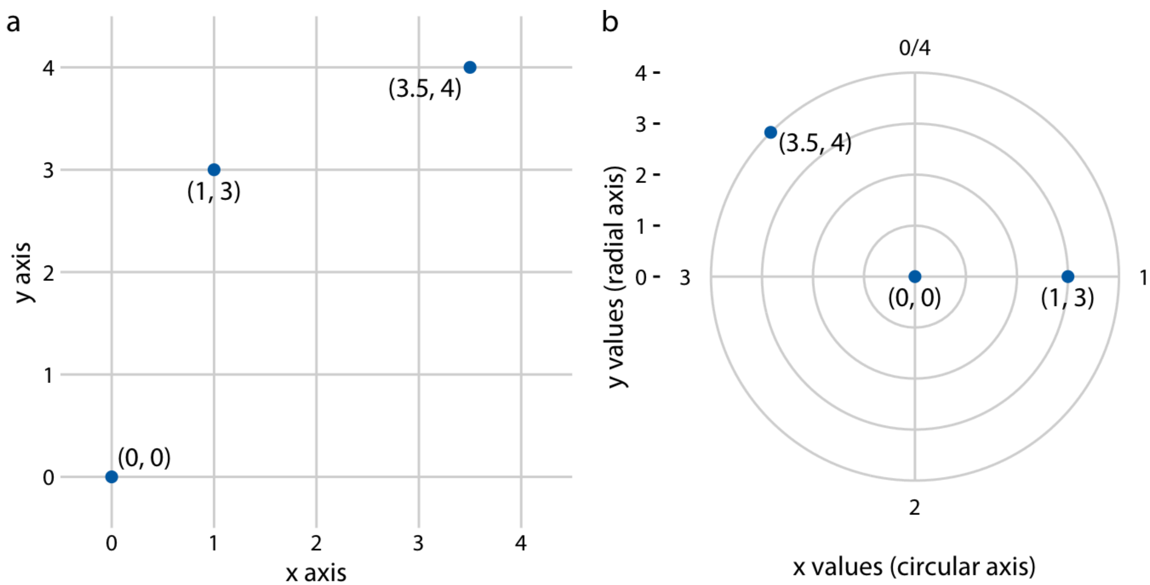


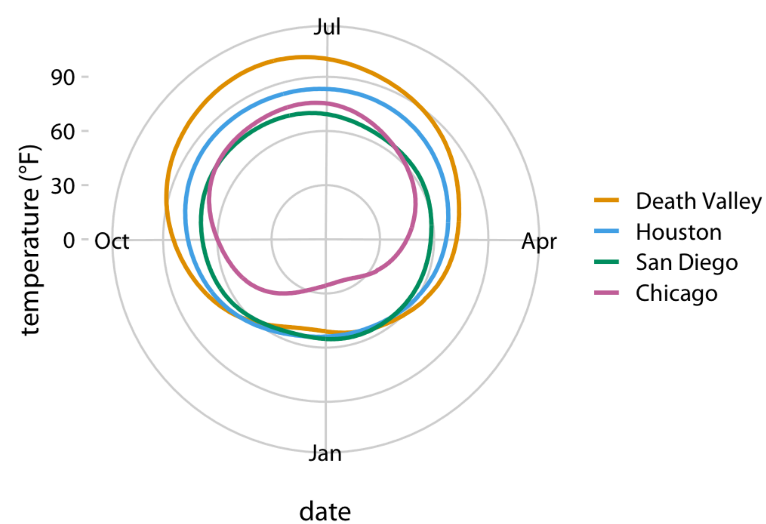
Non linera axes





Curved axes


a
y axis
x axis
0
1
2
3
4
(0, 0)
(1, 3)
(3.5, 4)
b
0/4
1
2
3
y values (radial axis)
x values (circular axis)
(0, 0)
(1, 3)
(3.5, 4)


Jul
Oct
Apr
Jan
90
60
30
0
temperature (°F)
date
Death Valley
Houston
San Diego
Chicago

Example

Table 2.2: First 12 rows of a dataset listing daily temperature normals for four weather stations. Data source: NOAA.

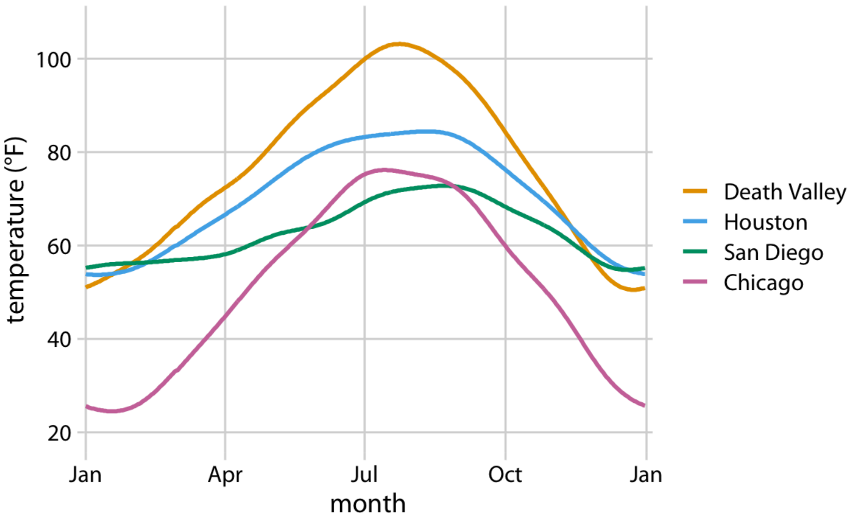
Month	Day	Location	Station ID	Temperature
Jan	1	Chicago	USW00014819	25.6
Jan	1	San Diego	USW00093107	55.2
Jan	1	Houston	USW00012918	53.9
Jan	1	Death Valley	USC00042319	51.0
Jan	2	Chicago	USW00014819	25.5
Jan	2	San Diego	USW00093107	55.3
Jan	2	Houston	USW00012918	53.8
Jan	2	Death Valley	USC00042319	51.2
Jan	3	Chicago	USW00014819	25.3
Jan	3	San Diego	USW00093107	55.3
Jan	3	Death Valley	USC00042319	51.3
Jan	3	Houston	USW00012918	53.8

Ordinal Ordinal Nominal Nominal Quantitative

Adapted from: Fundamental of Data Visualization, Claus O. Wilke, O'Reilly editor

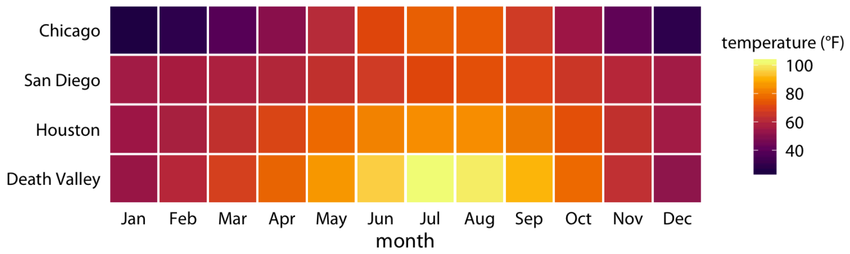
Example

- Temperature (quantitative) on a linear axis (y)
- Month and day (ordinal) on a linear axis (x)
- City (nominal) on a color hue scale



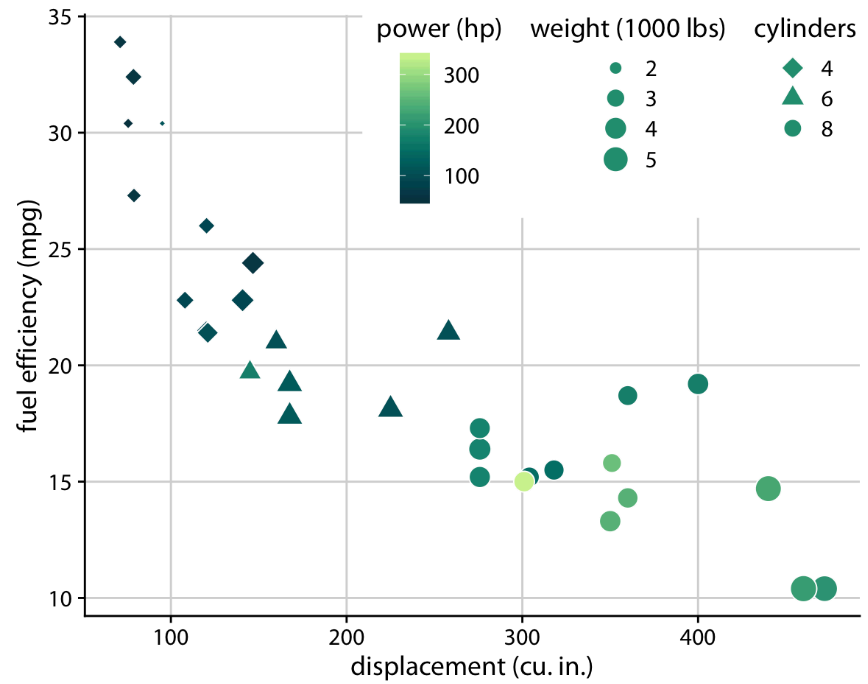
Example

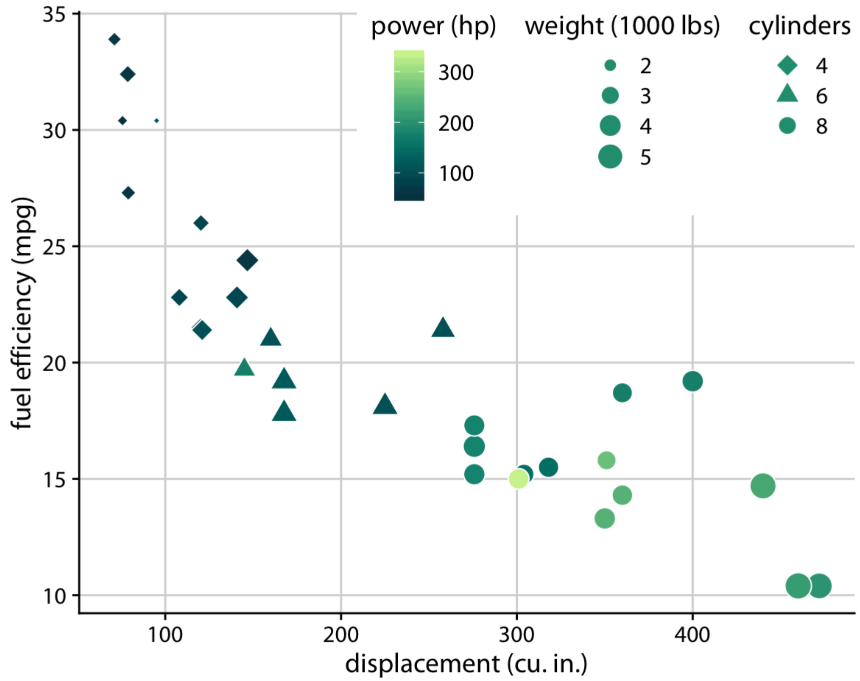
- Month (ordinal) on a ordinal axis (x)
- City (nominal) on a ordinal axis (y) (order determined on sum of temperatures on the line
- Temperature (quantitative) on a color scale

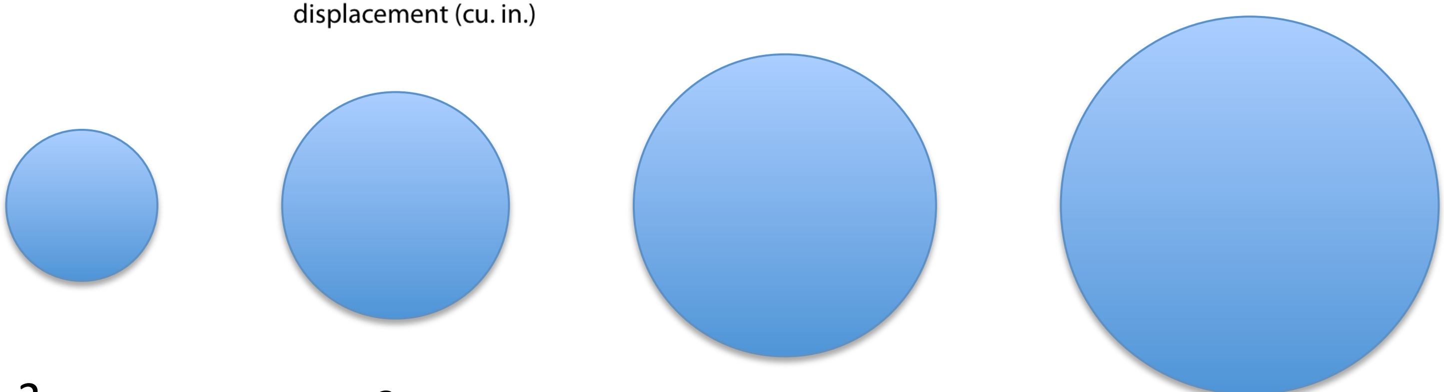


Example

- Displacement (quantitative) on linear axis (x)
- Fuel efficiency (quantitative) on linear axis (y)
- Power (quantitative) on lineal color scale
- Weight (quantitative -> ordinal) on ~~linear~~ squared size scale
- Cylinders (ordinal -> nominal) on shape scale







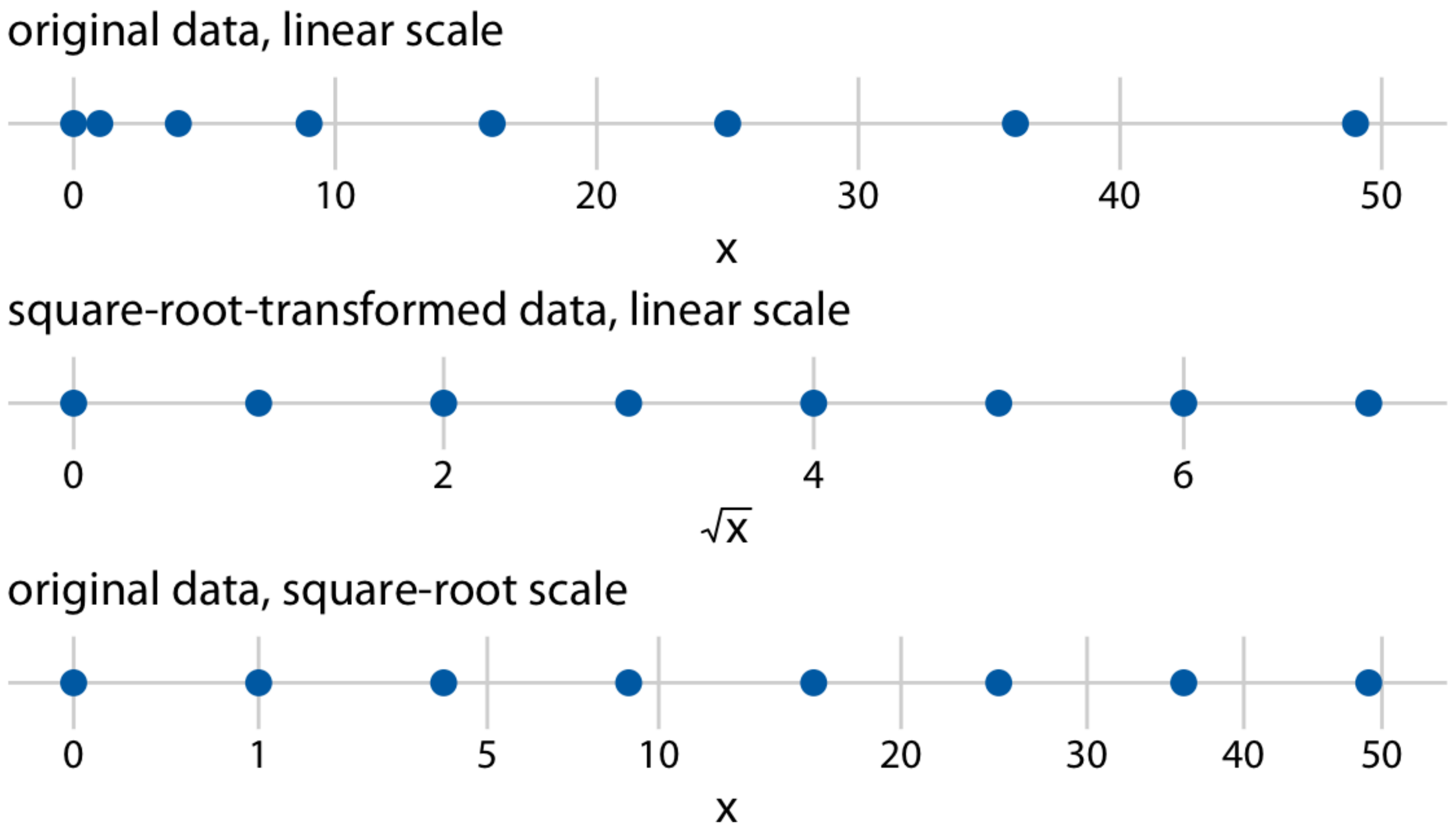
r=2
A = 4*PI

r=3
A = 9*PI

r=4
A = 16*PI

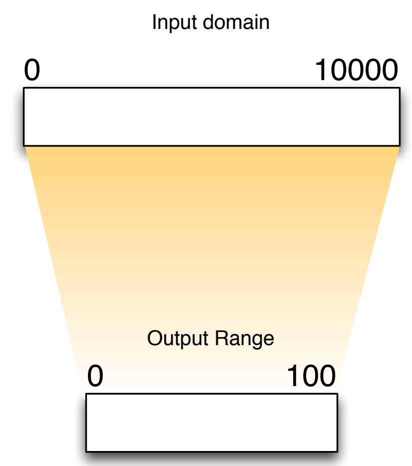
r=5
A = 25*PI

Non linear axes



Manual Mapping

1. For input domain
   1. Select the largest number in original interval (10000)
   2. Select the smallest number in original interval (0)
   3. Select the difference of the two values (10000)
2. For output range
   1. Select the largest number in the new interval (100)
   2. Select the minimum number in the new interval (0)
   3. Select the difference of the two values (100)
3. Compute the ratio of the two intervals' range (10000/100 = 100)



- This is an example of a linear scaling
  - y = mx +b, where b=0 and m=1/100
  - 100 units in the original interval correspond to 1 unit in the destination interval

An example – an alternative solution

```
join.enter()
    .append("rect")
    .attr("x", function(d,i){
        return i*barw;
    })
    .attr("y",function(d){
        return height - d*4;
    })
    .attr("width", barw)
    .attr("height",function(d){
        return d*4;
    });
```

```
join.enter()
    .append("rect")
    .attr("x", function(d,i){
        return x(i);
    })
    .attr("y",function(d){
        return y(d);
    })
    .attr("width", barw)
    .attr("height",function(d){
        return h(d);
    });
function x(d){return m*d + b};
function y(d){return m'*d + b'};
function h(d){return m''*d + b''};
```

D3.js Scales generator

- D3 provides several scale types
  - Quantitative
    - Continuous
      - Identity
      - Linear (y=mx+b)
      - Power (y=mx^k+b)
      - Log (y=m log(x) + b)
    - Discrete
      - Quantize
      - Quantile
      - Threshold
  - Ordinal
  - Time

Creating a scale

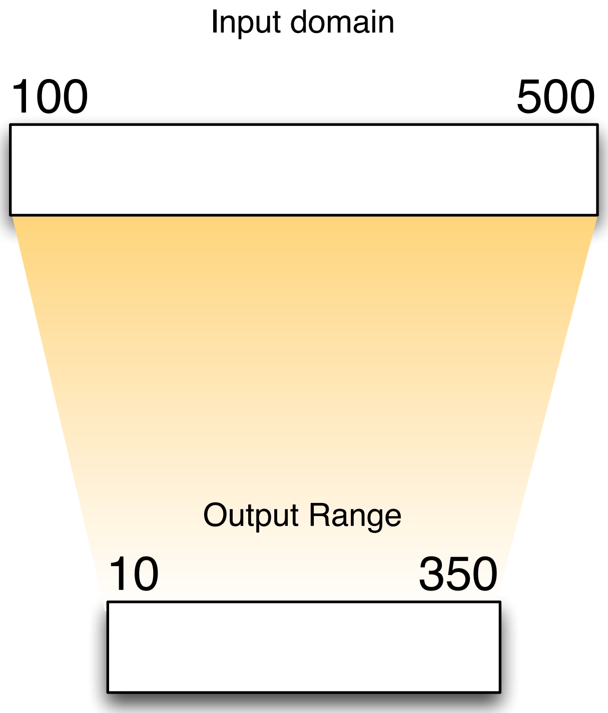
```
var scale = d3.scaleLinear();
```

- Default scale uses
  - Domain is [0,1]
  - Range is [0,1]
  - Function is Identity
  - `scale(2.5); //returns 2.5`

Creating a scale – setting domain and range

```
var scale = d3.scaleLinear()
    .domain([100,500])
    .range([10,350]);
```

- Default scale uses
  - `scale(100); //returns 10`
  - `scale(300); //returns 180`
  - `scale(500); //returns 350`



Quantitative power scale – circle radius

Previous example

```
g.append("circle")
    .attr("fill","pink")
    .attr("stroke","red")
    .attr("r",function(d){
        return Math.sqrt(d*100);
    })
```

Refined solution

```
var r = d3.scaleSqrt()
    .domain([0,20])
    .range([0,30];

g.append("circle")
    .attr("fill","pink")
    .attr("stroke","red")
    .attr("r",function(d){
        return r(d);
    })
```

Utility functions: d3.min, d3.max, d3.extent

- To determine the domain and range interval we should know min and max of the two intervals
- D3.js provides utility functions to access such values
  - `d3.min(array[,accessor])`
  - `d3.max(array[,accessor])`
  - `d3.extent(array[,accessor])`

Utility Functions: examples

```
d3.min([10,30,40,70,100]) //returns 10
d3.max([10,30,40,70,100]) //returns 100
d3.extent([10,30,40,70,100]) //returns
[10,100]
```

Domains & Ranges

- Typically, domains are derived from data while ranges are constant.

```
var x = d3.scaleLinear()
    .domain([0, d3.max(numbers)])
    .range([0, 720]);
```

```
var x = d3.scaleLog()
    .domain(d3.extent(numbers))
    .range([0, 720]);
```

```
function value(d) { return d.value; }

var x = d3.scaleLog()
    .domain(d3.extent(objects, value))
    .range([0, 720]);
```

ObservableHQ – Introduction to D3.js Scales

Observable | Search | ··· | Fork | New

D3 • d3js.org
Bring your data to life.
By Fil

5

Published Jun 24, 2019 | 1 Fork | Listed in d3-scale

Introduction to D3's scales

When, on a print map, 1 cm figures a real distance of 1 km on the terrain, we say that the map has a 1:100,000 scale.

But scales are not limited to a proportional ratio (or rule of three) between an actual distance and a length on paper. More generally, they describe how an actual dimension of the original data is to be represented as a visual variable. In this sense, scales are one of the most fundamental abstractions of data visualization.

Scales from the d3-scale module are functions that take as input the actual value of a measurement or property. Their output can in turn be used to encode a relevant representation.

```
ƒ(t)
d3.scaleLinear()
```

A scale thus maps a physical quantity (or, more generally, an observation), which might be expressed in meters, kilograms, years or seconds, number of horses in a field… to a length or a radius (in screen pixels or print centimeters), a color (in CSS representation), a shape…

Domain and range

A scale has to know from whence this observation comes — and this is called its

https://observablehq.com/@d3/introduction-to-d3s-scales

ObservableHQ – Discrete Scales

```
jenks = ƒ(n)

jenks = d3
  .scaleThreshold()
  .domain([53440, 135096])
  .range(["white", "pink", "red"])
```


```
showScaleGrouping(data, {
  scaleQuantile: quantile,
  scaleThreshold: threshold,
  scaleJenks: jenks,
  scaleQuantize: quantize,
  scaleQuantizeNice: quantize.copy().nice()
})
```

https://observablehq.com/@d3/quantile-quantize-and-threshold-scales

ObservableHQ – Sequential Scales

```
angryRainbow(t0)
```

```
viewof t0 = ramp(angryRainbow)
```

Note. Besides demonstration purposes, this color scheme is not recommended. Its is not perceptually uniform (most people will see spikes around the yellow, light blue and pink colors — hence the "angry rainbow" nickname); d3-scale-chromatic provides better alternatives for cyclical color scales, such as d3.interpolateSinebow:

```
"rgb(255, 64, 64)"
d3.interpolateSinebow(t1)
```

```
viewof t1 = ramp(d3.scaleSequential(d3.interpolateSinebow))
```

(All manners of sequential color scales are available in the d3-scale-chromatic module: diverging, single-hue, multi-hue and cyclical.)

sequential.interpolator allows to read or modify the interpolator function *f* in an existing sequential scale. It can be useful to construct a scale iteratively... see Curran Kelleher's block for an example. We use it below to read a scale's interpolator and create a mirror image (by applying it to 1–*t* instead of *t*):

```
{
```

https://observablehq.com/@d3/sequential-scales

ObservableHQ – Diverging Scales

```
chart(scaleAnomalyPuOr) // chart is defined in the Annex, below
```

While the “PuOr” (purple-orange) interpolator looks good, we’ll prefer in this case a blue (for negative) to red (for positive) color interpolator, passing through white (for neutral). The interpolator is a function that takes its inputs in [0,1], and we’re free to create our own.

As D3 offers a standard “RdBu” diverging color interpolator, that goes from red to white to blue. Almost what we needed: we’ll just reverse it to blue-white-red, by applying it to (1–*t*) instead of *t*.

The interpolator can be given, in a shorthand notation, as an argument to d3.scaleDiverging, so our final code is:

```
scaleAnomaly = f(n)
```

```
scaleAnomaly = d3.scaleDiverging(t => d3.interpolateRdBu(1 - t))
  .domain([extent[0], 0, extent[1]])
```

```
chart(scaleAnomaly)
```

To be complete, the shorthand notation also accepts the domain as an optional first argument:

```
chart(d3.scaleDiverging([extent[0], 0, extent[1]], t => d3.interpolateRdBu(1 - t)))
```

Variations are another typical use case: to visualize a value change on a map (in that

https://observablehq.com/@d3/diverging-scales

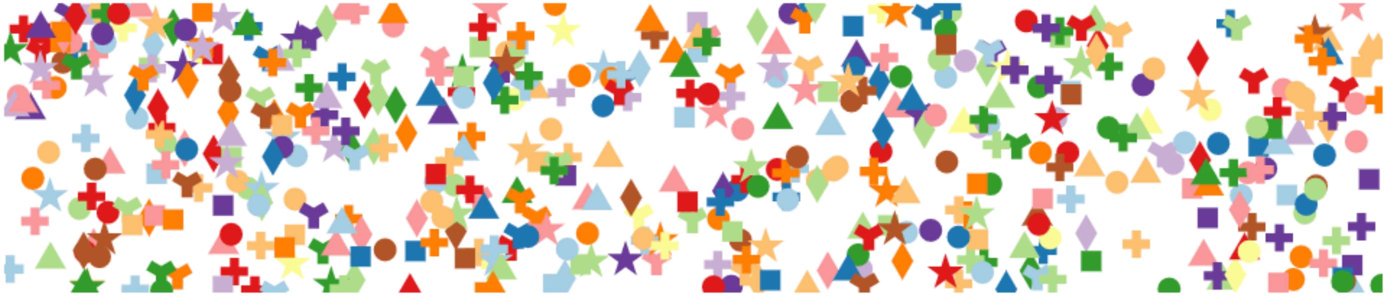
ObservableHQ – Qualitative Scales

Colors & Symbols

Color palettes are a quite common use case for ordinal ranges. You are encouraged to create your own, by hand or using one of the many tools available, but you can also use the list of color schemes provided by d3-scale-chromatic.

A | list | of | twelve | words | to | explore | d3 | schemePaired | color | scheme | !

A useful range for an ordinal scale can be a set of symbols that will used to draw shapes, like for instance d3.symbols.



```
{
  const symbols = d3.scaleOrdinal().range(d3.symbols),
    color = d3.scaleOrdinal(d3.schemePaired),
    height = 200,
    symbol = d3.symbol().size(200),
    data = d3.range(500).map(i => ({
      x: width * Math.random(),
      y: height * Math.random(),
      s: Math.floor(9 * Math.random()),
```

https://observablehq.com/@d3/d3-scaleordinal