# 3. More Advanced Graphics

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# Outline

- Colour and pre-attentive perception: *facts* about graphics
- Too many variables: parallel coordinates, transparency
- Too many dimensions: hexagonal binning, transparency

# Colour coding

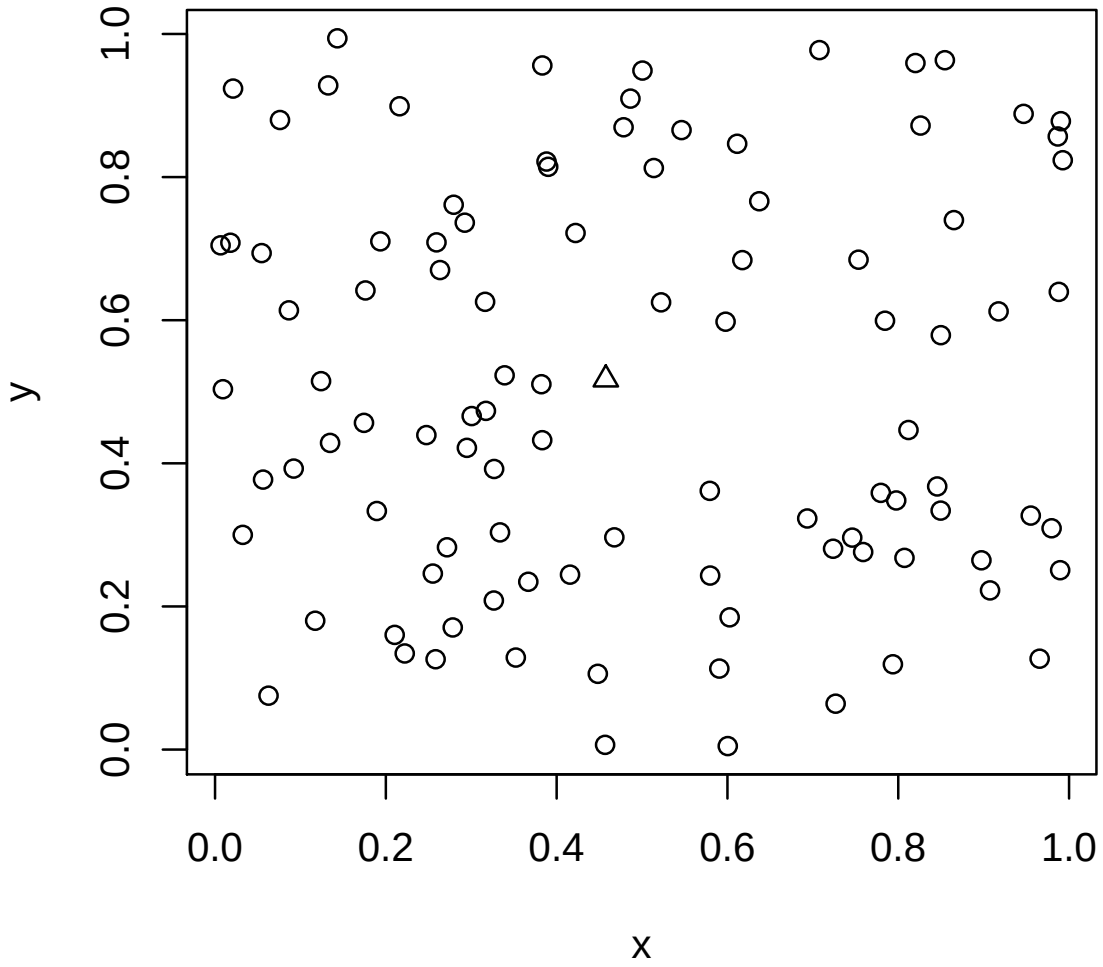
'Simple' plots involve two-dimensional data, which we measure on the $x$ and $y$ axes.

For higher-dimensions, some traditional approaches are;

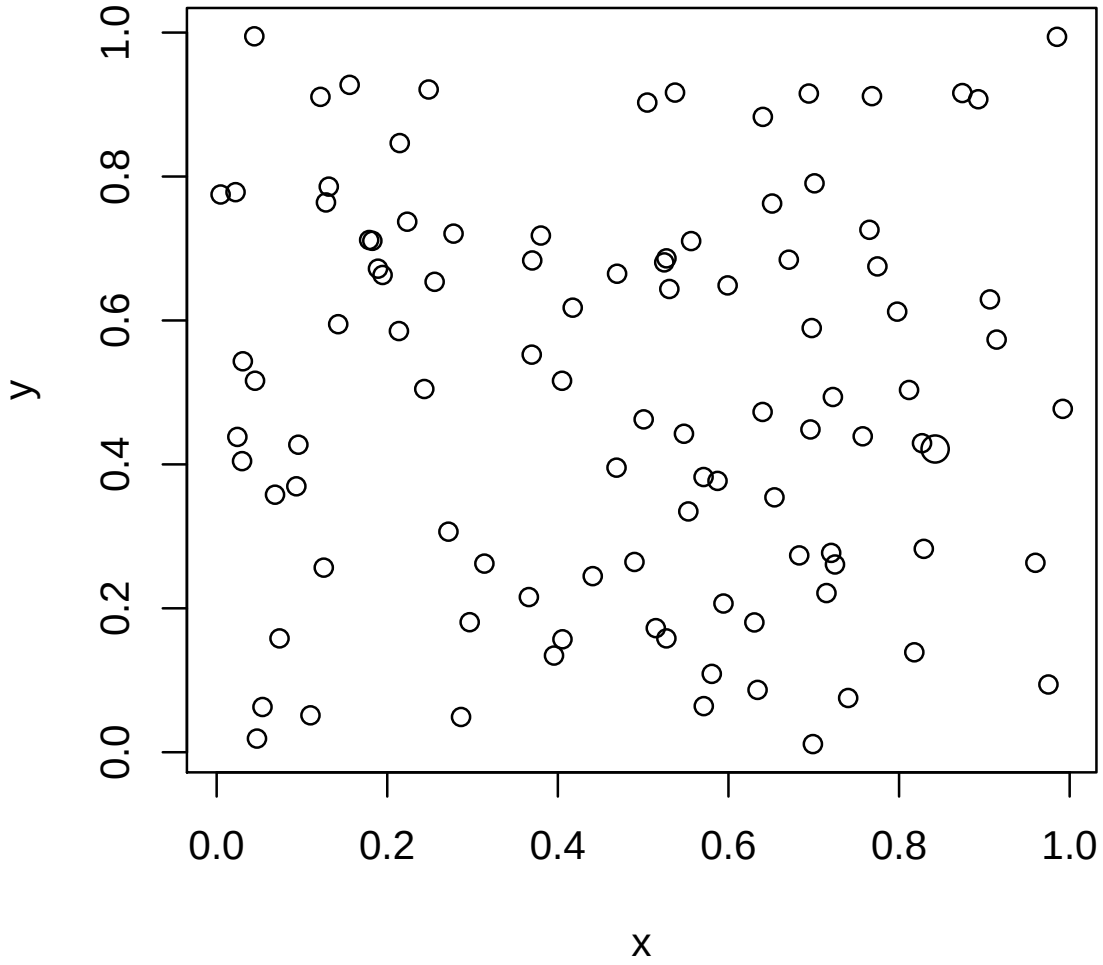
- Different colors for e.g. men, women (`col`)
- Different-shaped symbols (`pch`), or different sizes (`cex`)

For $\leq$ 100's of data points, modest use of these is fine. But your eye is not good at concentrating e.g. just on the purple points, in a fully Technicolor plot;

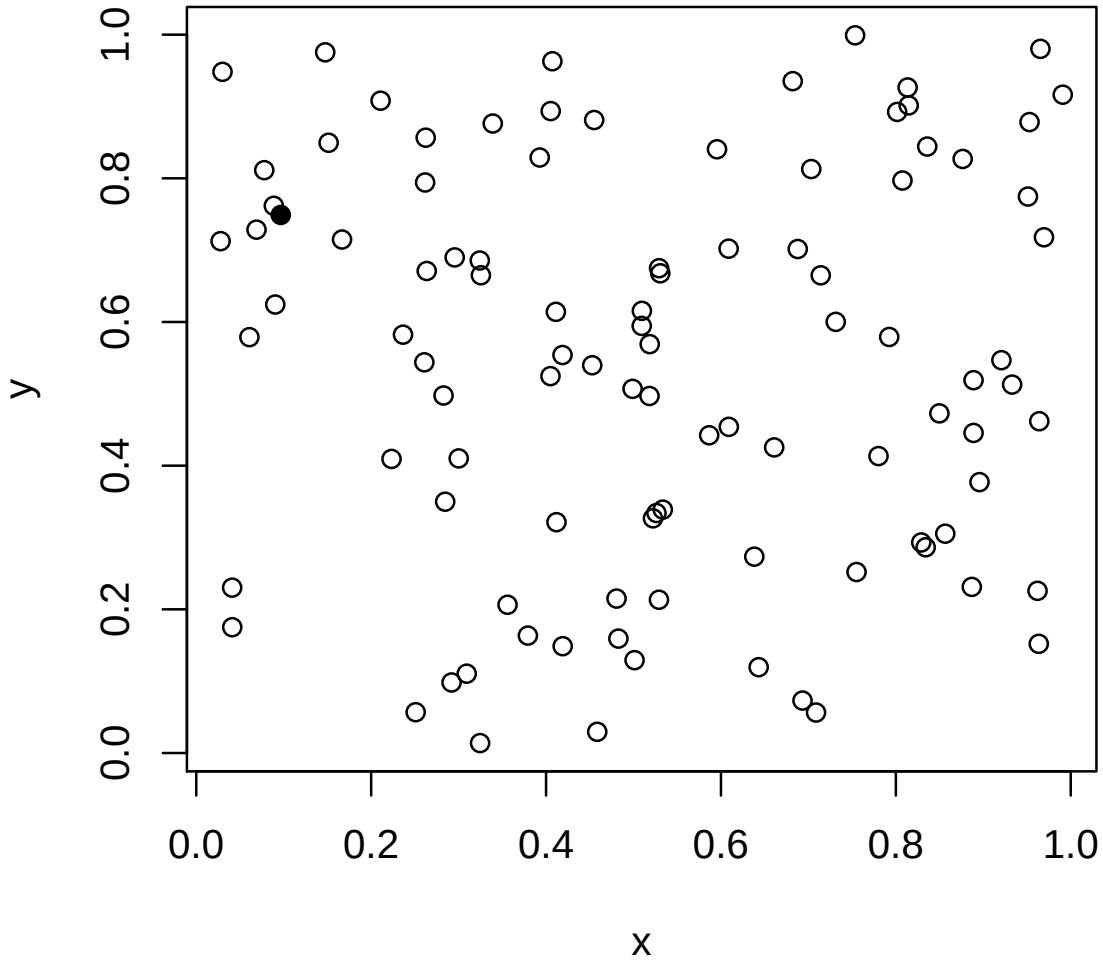
# Which point is different?



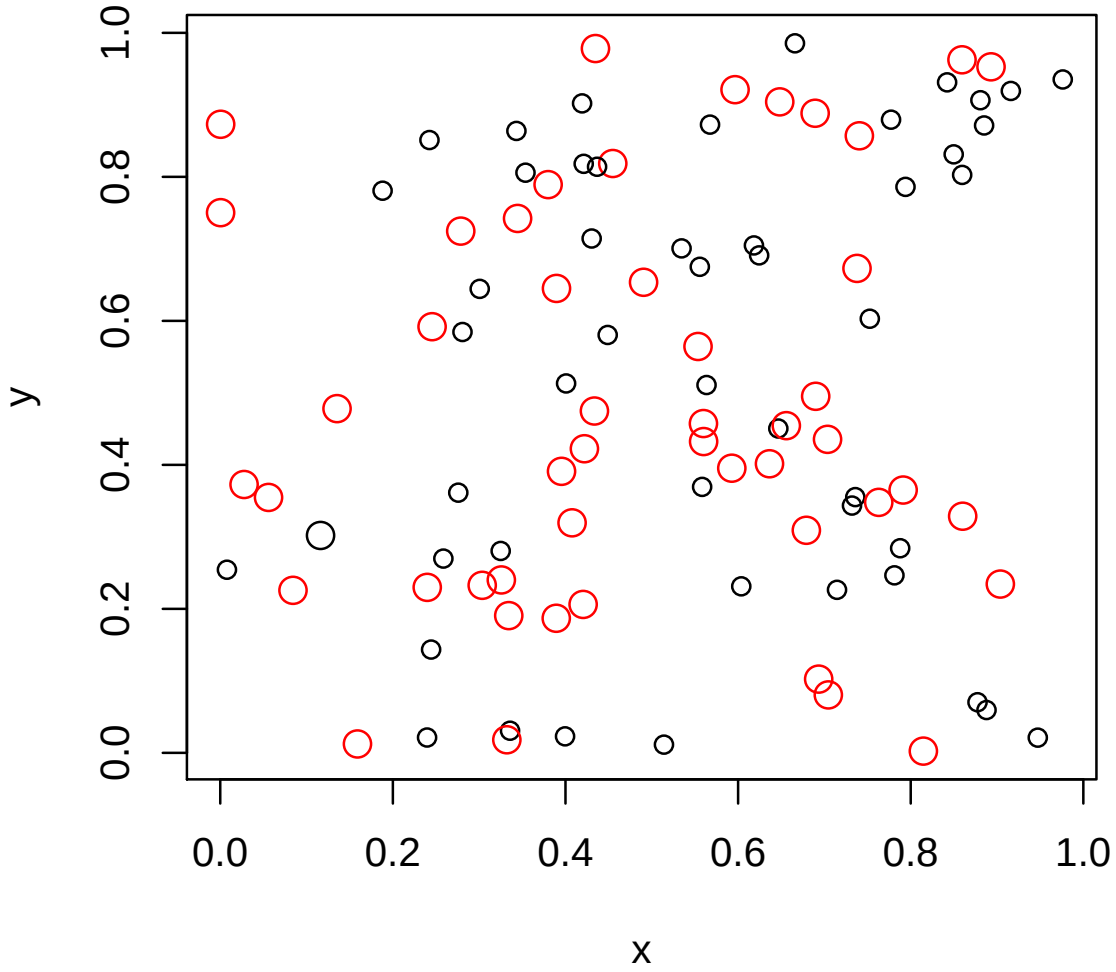
# Which point is different?



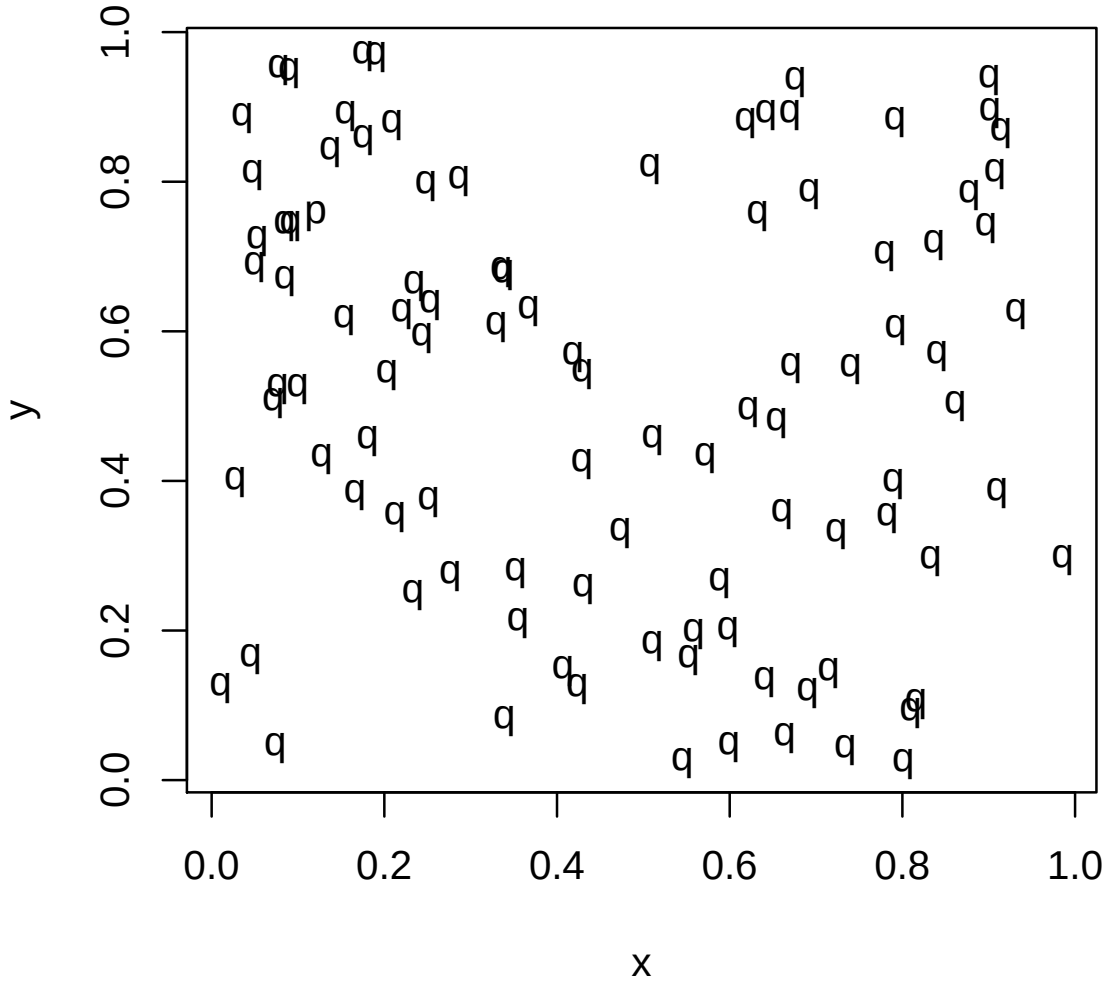
# Which point is different?



# Which point is different?



# Which point is different?



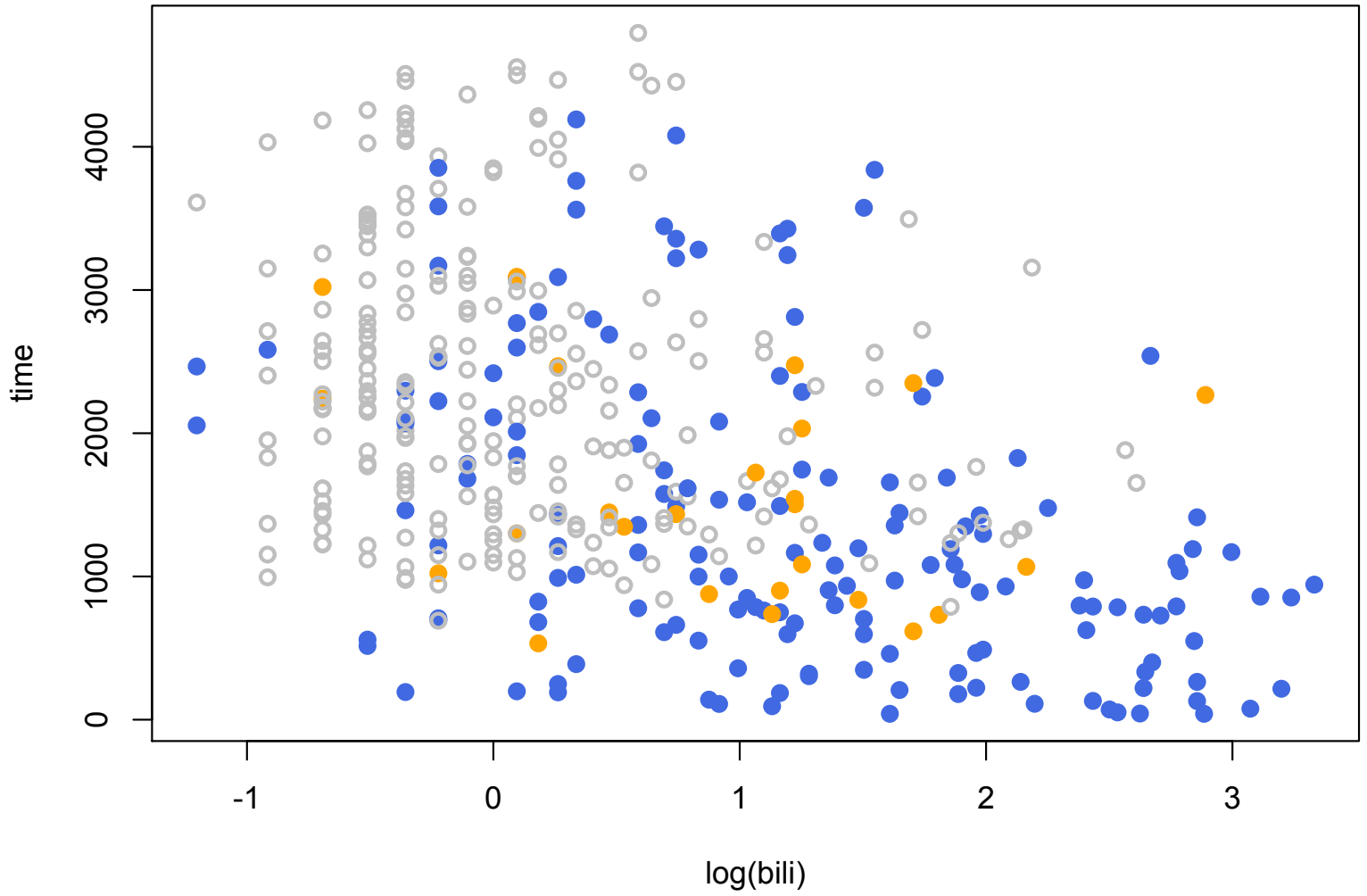
# Preattentive perception

Some differences are processed by the brain before you get to see the image: this is *pre-attentive perception*.

It's important because;

- It's easier to see things
- You can look at just one subset of the points and see patterns
- Like colour-blindness, illustrates that there are *facts* about graphics, not just questions of artistic taste

# Preattentive perception



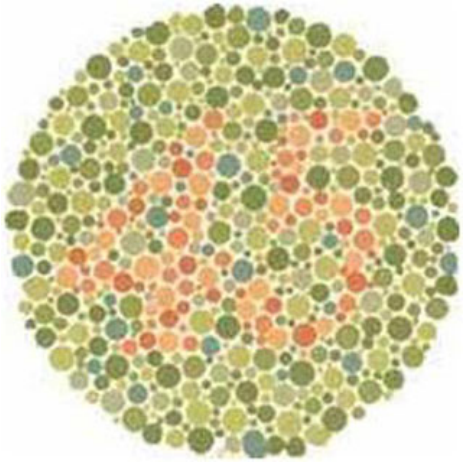
# Color schemes

Color choice is best left to experts... or people with taste.

http://www.colorbrewer.org has color schemes designed for the National Cancer Atlas, also in package RColorBrewer

colorspace package has color schemes based on straight lines in a perceptually-based color space (rather than RGB).

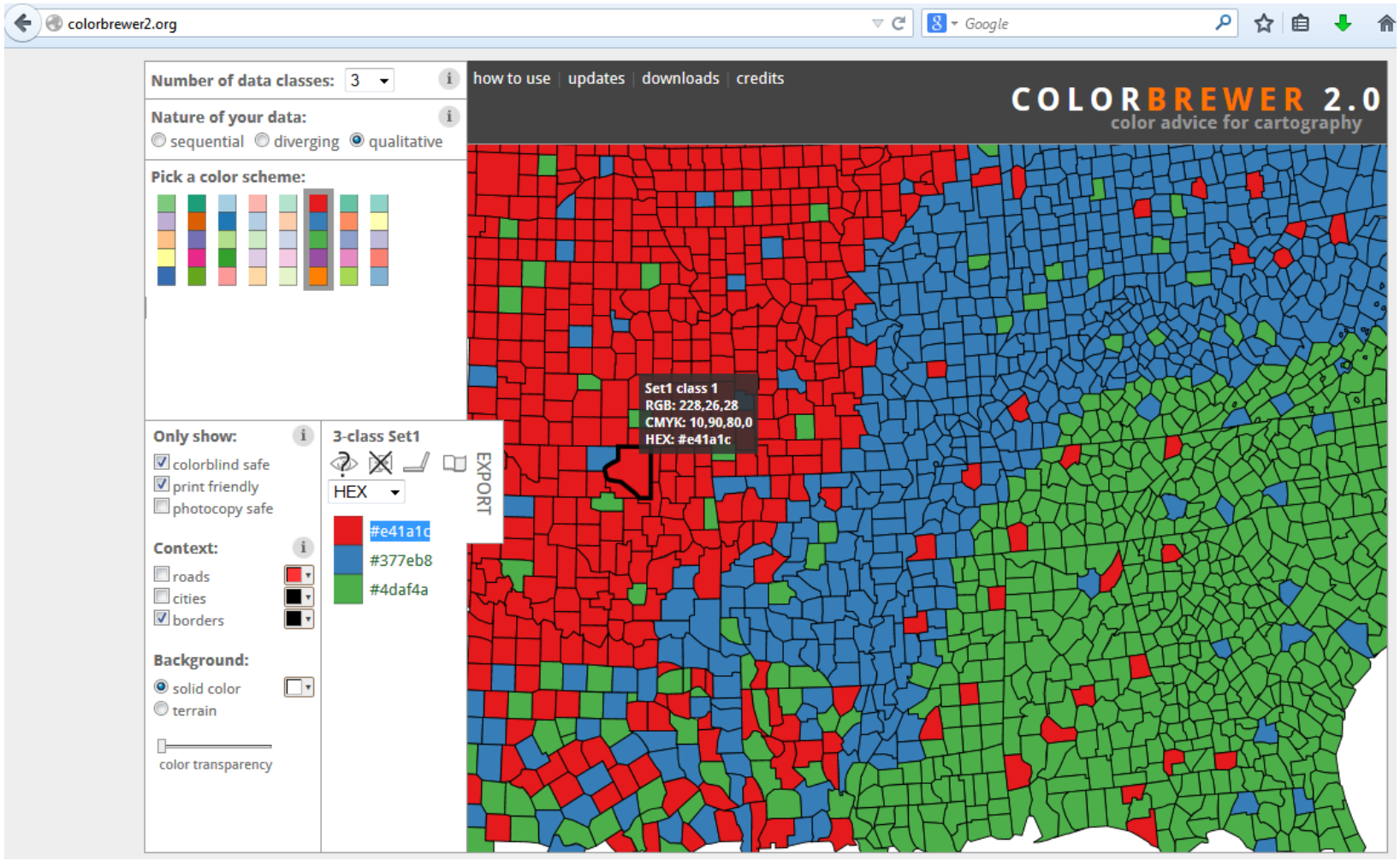
dichromat package attempts to show the impact of red:green color blindness on your R color schemes.



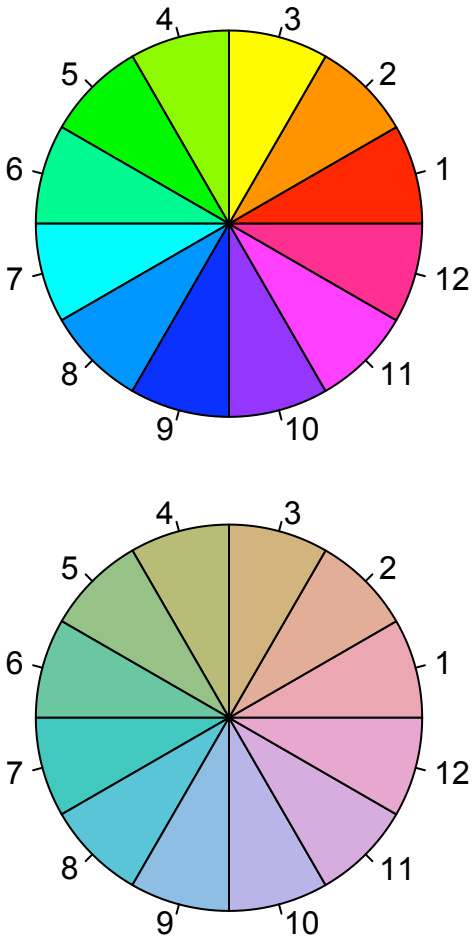
[Code for examples is in file colorpalettes.R on course website]

# Color brewer

R accepts 'hex' colors, e.g. `col="#e41a1c"` here;

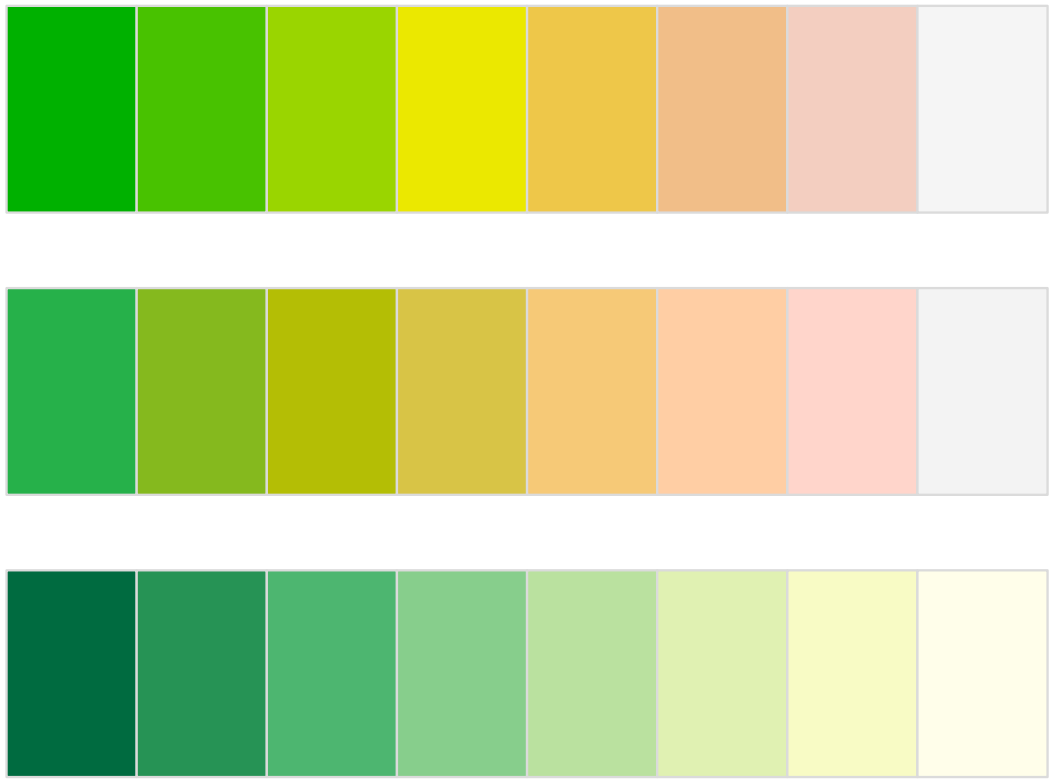


# Color choice



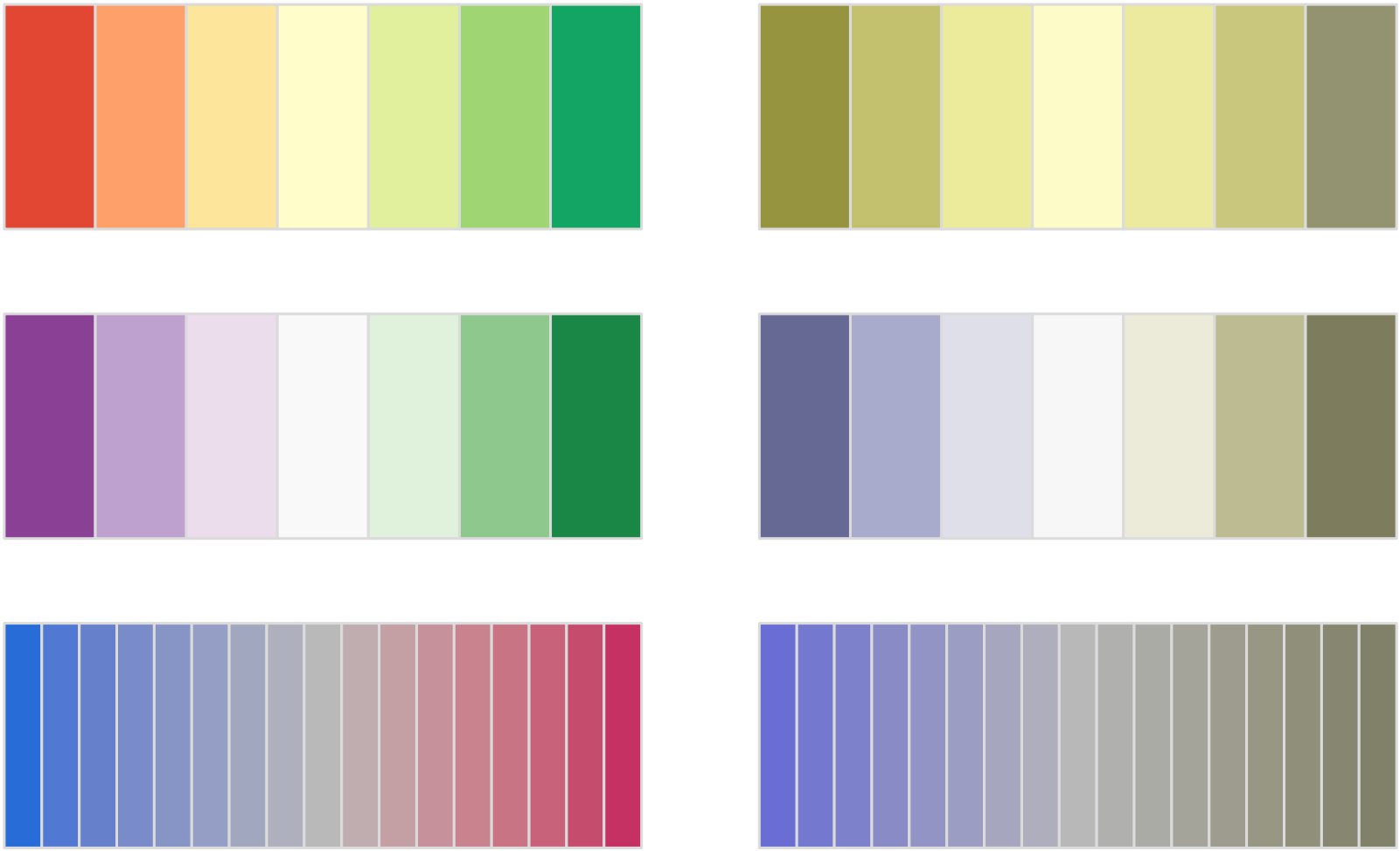






(nb B&W printed copies of this slide may not be helpful!)

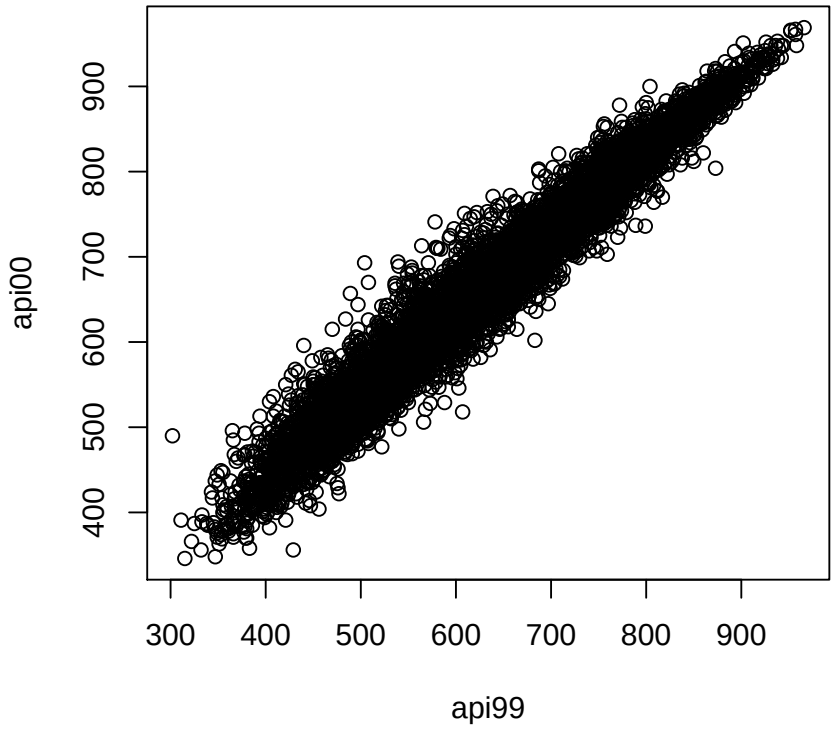
# Color blindness



(nb B&W printed copies of this slide may not be helpful!)

# Larger data

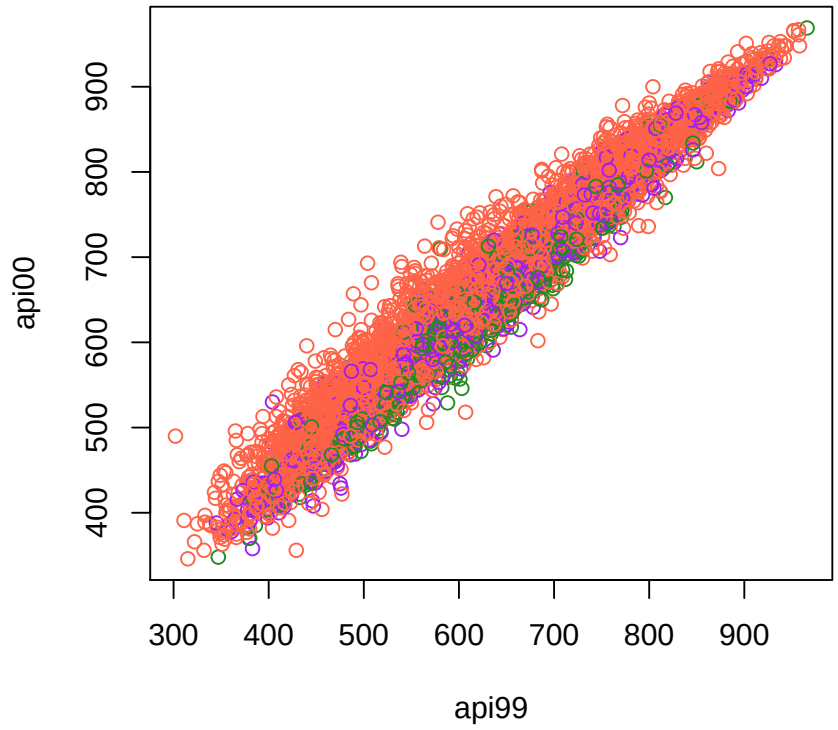
For large(ish) data, 'overlap' is a fundamental problem...




(California Academic Performance Index on 6194 schools)

# Larger data

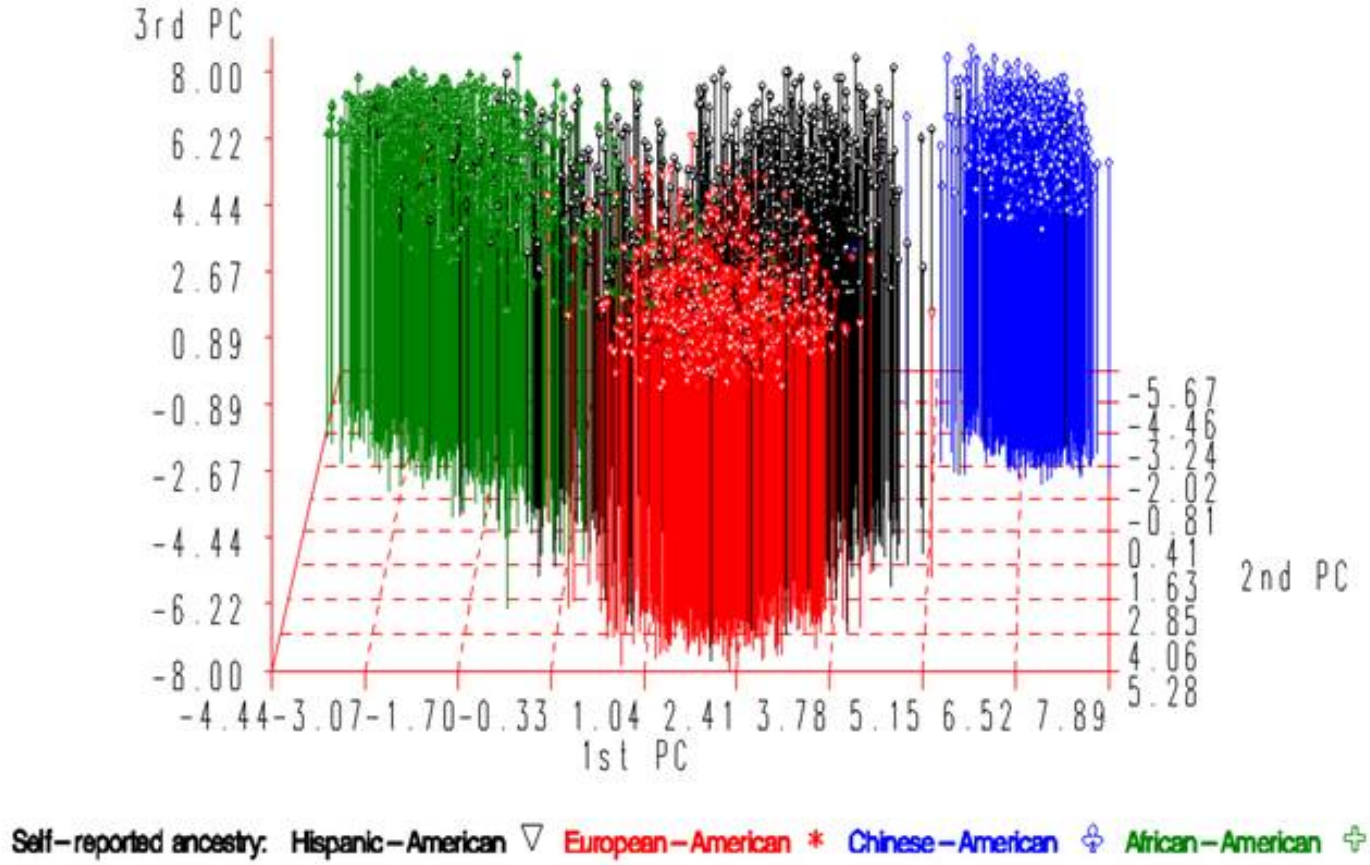
... which remains, when we color-code.




Colors denote Elementary, Middle & High Schools

# Larger data

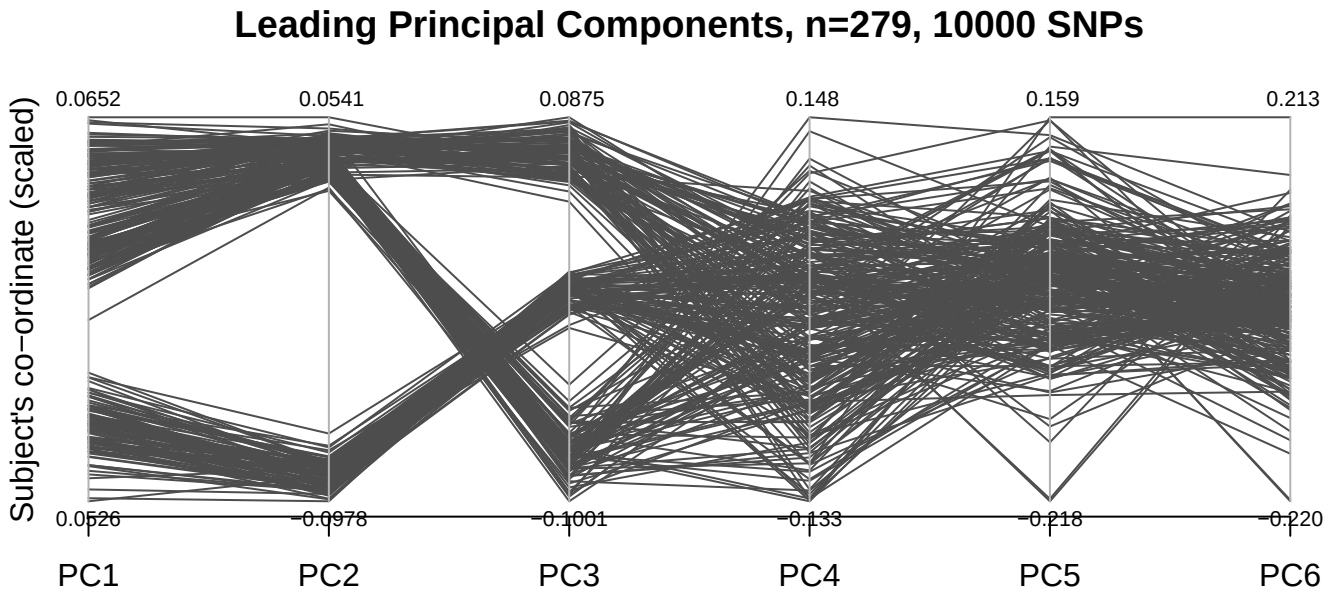
With three dimensions + color-codes, this can happen;




(R does have `persp()`, for occasional use)

# Parallel Coordinate Plots

For even higher-dimensional data, scatterplots can not provide adequate summaries. For data where the dimensions can be ordered, the parallel co-ordinates plot is useful;

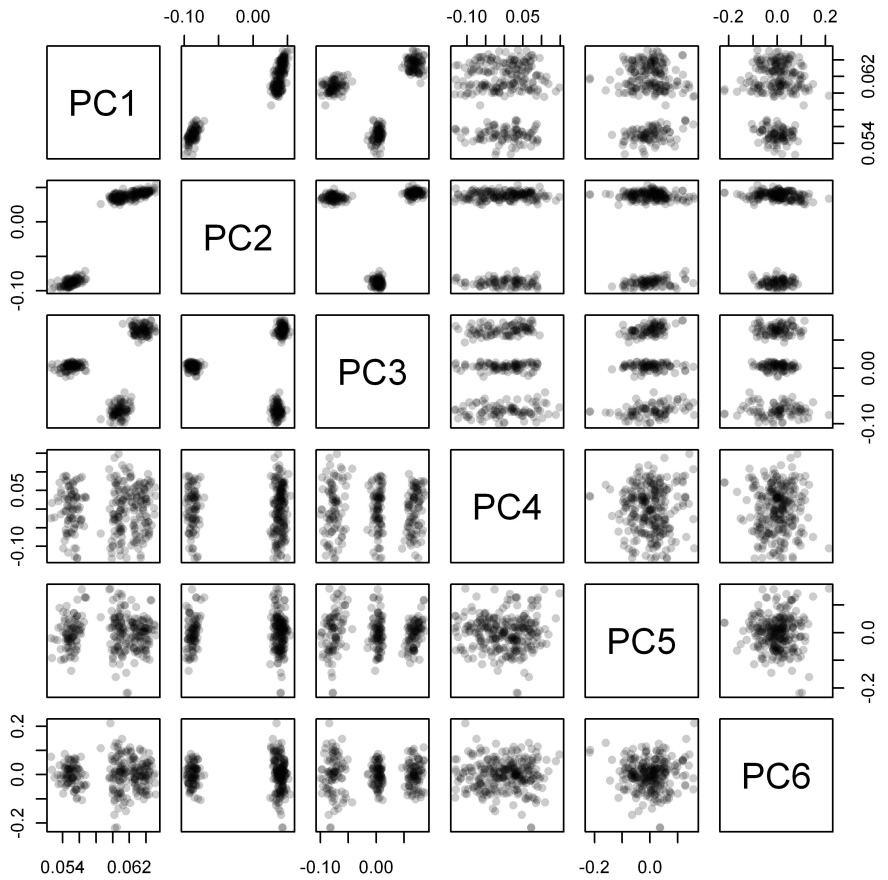


# Parallel Coordinate Plots

- Each multi-dimensional data point (i.e. each person) is represented by a line – not a point
- `parcoord()` in the `MASS` package is one simple implementation – writing your own version is not a big job
- Coloring the lines also helps (example later)
- Scaling of axes, and their vertical positions are arbitrary
- Doing 'Principal Components Analysis' is just choosing axes for your data so that their variance is maximized on axis 1, then axis 2, ...

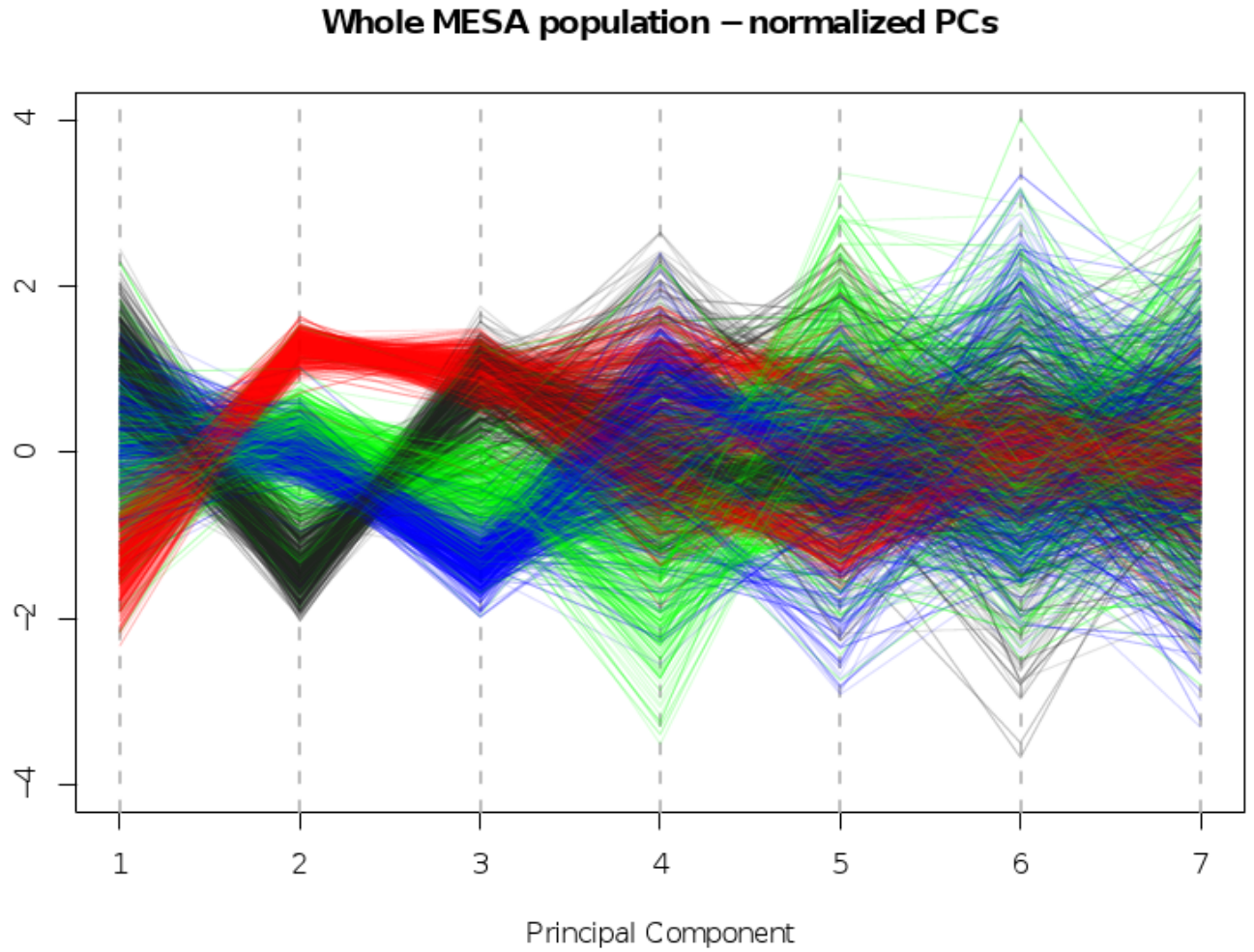
# Parallel Coordinate Plots

A `pairs()` plot of the same thing; (nasty!)



# Parallel Coordinate Plots

The pin cushion data++ : colors indicate self-report ancestry



# Transparency

The colors in the last examples were transparent. As well as specifiying e.g. `col=2` or `col="red"`, you can also specify

```
col="#FF000033"
```

– coded as RRGGBB in hexadecimal, with transparency 33 (also hexadecimal). This is a 'pale' red – 33/FF $\approx$ 20%.

Get from color names to RGB with `col2rgb()`, and from base 10 to base 16 using `format(as.hexmode(11), width=2)`

(Or, go to colorbrewer or some similar site and take the hex from there!)

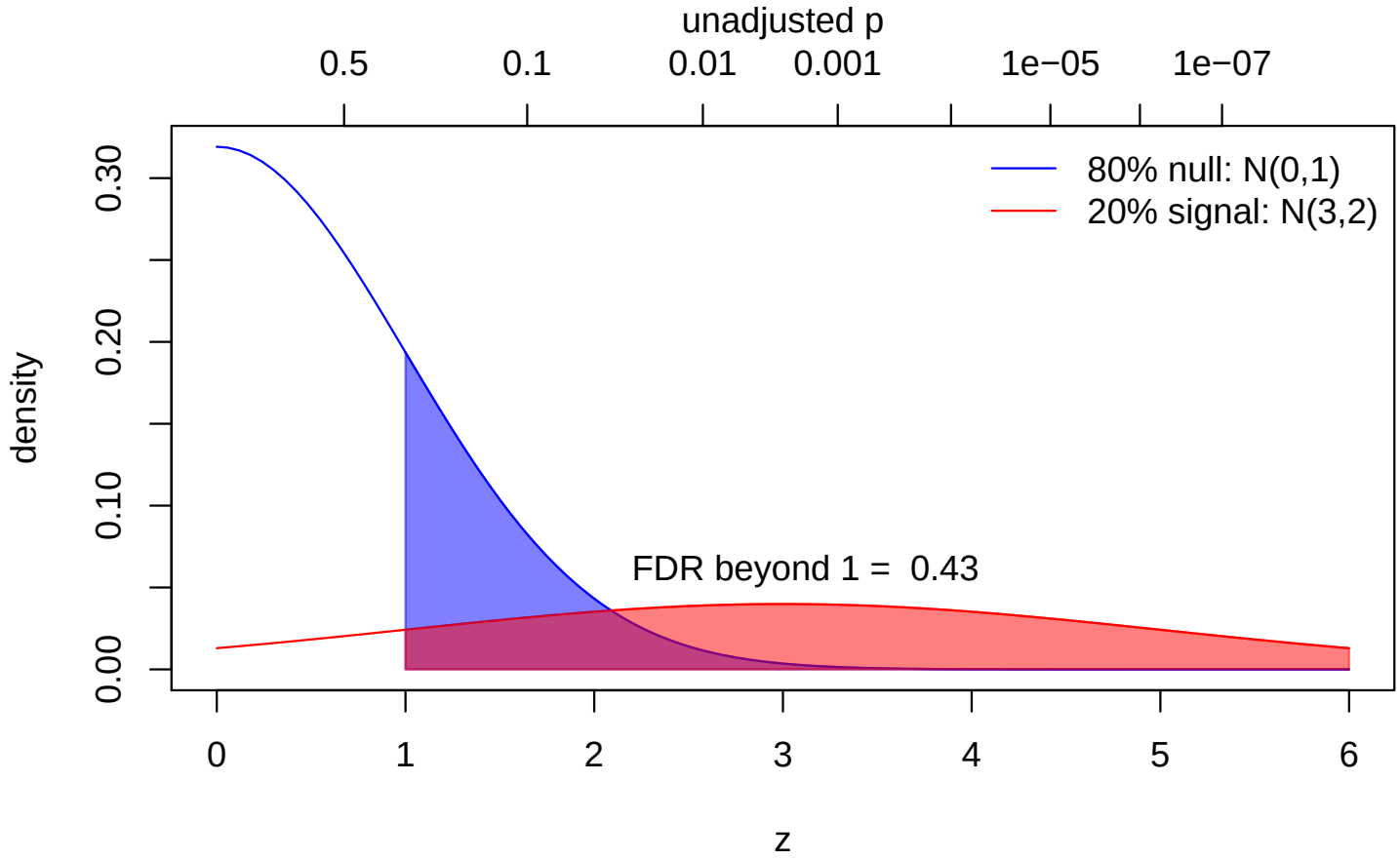
# Transparency

An example; (also shows other graphics commands)

```
curve(0.8*dnorm(x), 0, 6, col="blue", ylab="density", xlab="z")
curve(0.2*dnorm(x,3,2), 0, 6, col="red", add=T)

xvals <- seq(1, 6, l=101)
polygon(
c(xvals,6,1), c(0.8*dnorm(xvals), 0,0),
density=NA, col="#0000FF80" ) # tranparent blue
polygon(
c(xvals,6,1), c(0.2*dnorm(xvals,3,2), 0,0),
density=NA, col="#FF000080" ) # tranparent red

legend("topright", bty="n", lty=1, col=c("blue","red"),
c("80% null: N(0,1)", "20% signal: N(3,2)"))
axis(3, at=qnorm(c(0.25, 0.5*10^(-1:-7)), lower=F), c(0.5, 10^(-1:-7)) )
mtext(side=3, line=2, "unadjusted p")

text(2.2, 0.07, adj=c(0,1), paste("FDR beyond 1 = ",
round(0.8*pnorm(1,lower=F)/(0.8*pnorm(1,lower=F) + 0.2*pnorm(1,3,2,lower=F)),3)))
```

# Transparency

Here's the output;



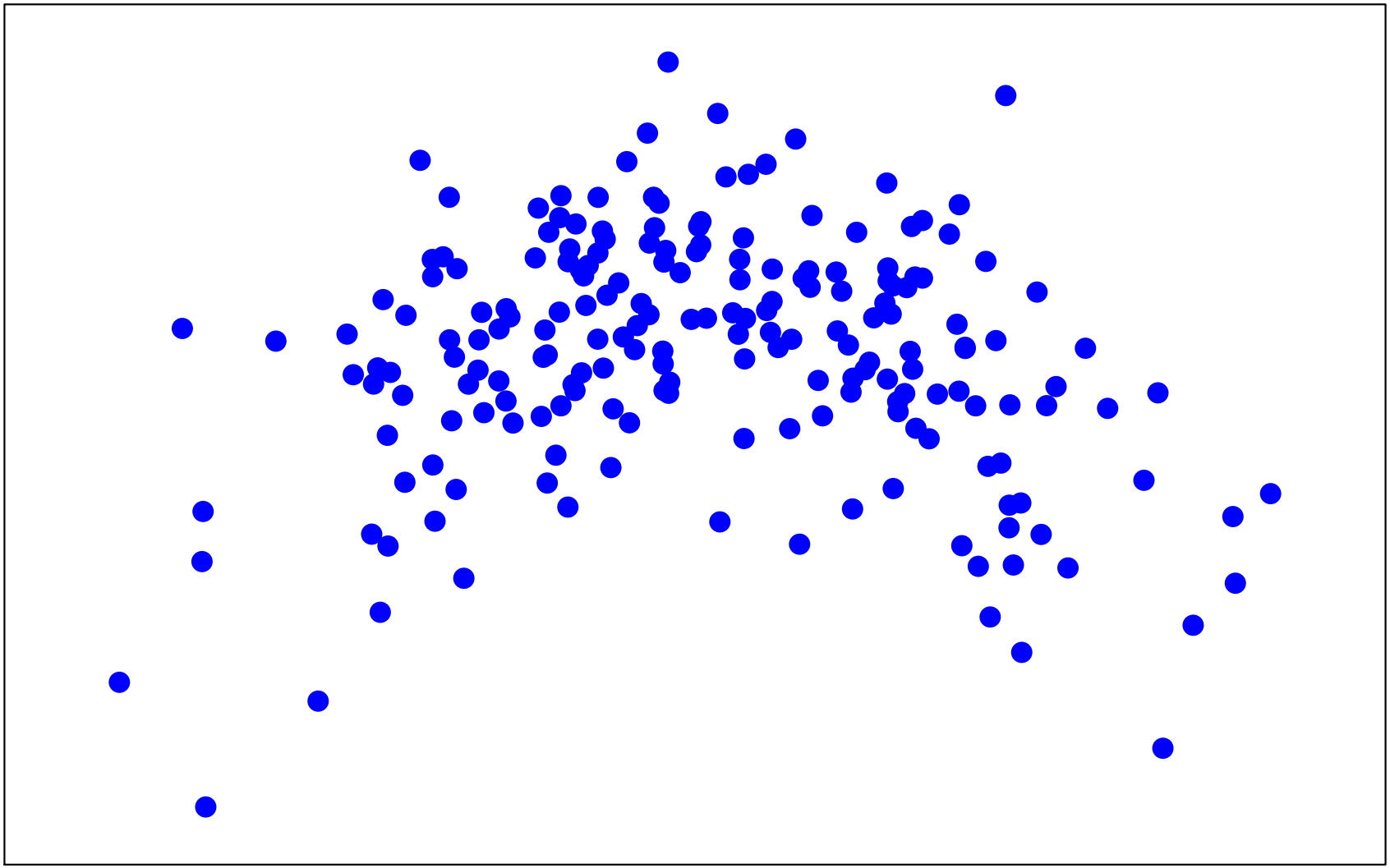
# Hexagonal binning

Using transparent plotting symbols is a quick-and-dirty way to adapt scatterplots for use with large datasets.

A better method is ‘hexagonal binning’; this is a 2D analog of a histogram – where you would count the number of data in one area, and then draw a bar with height proportional to that count.

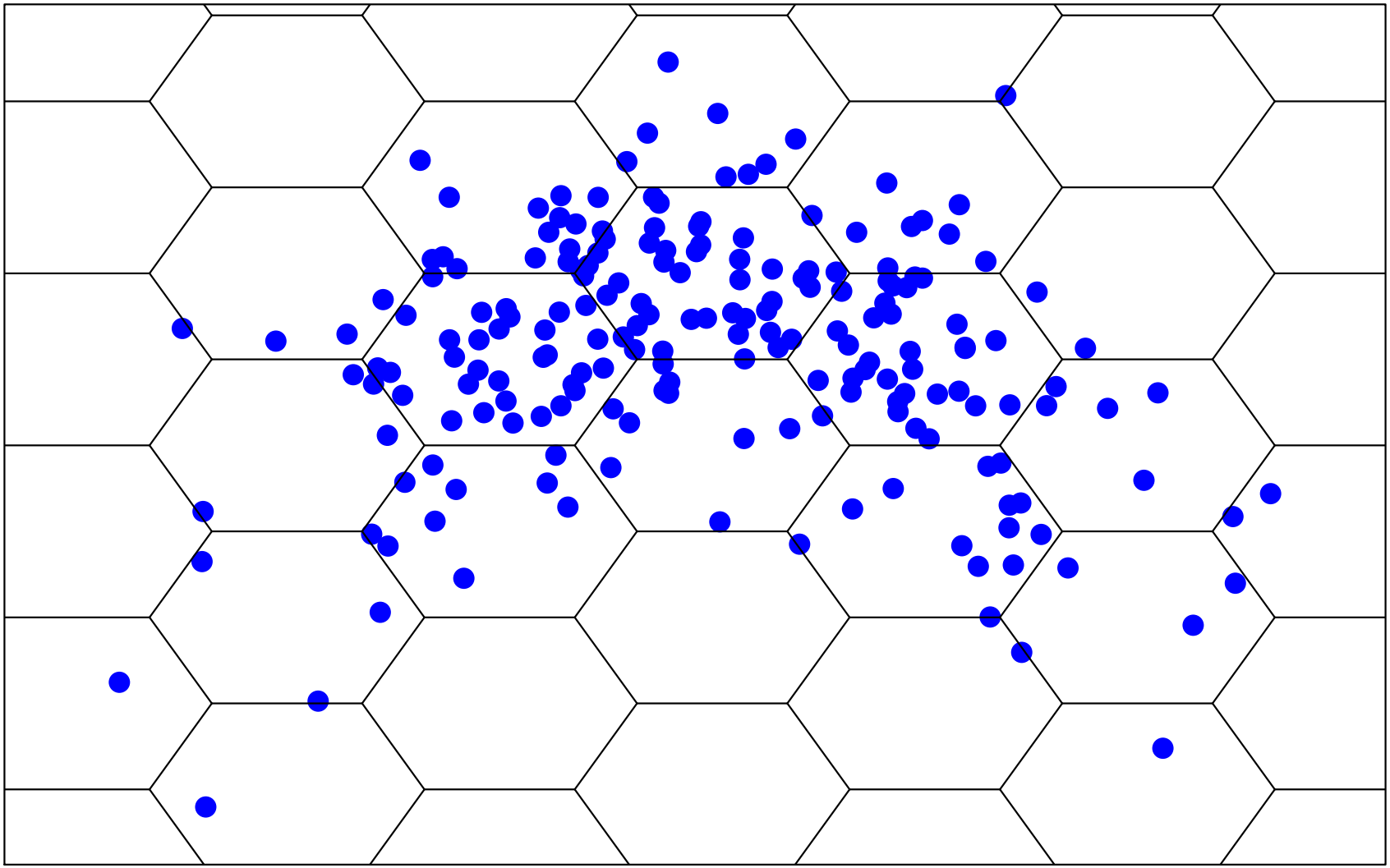
# Hexagonal binning

Binning in two dimensions;



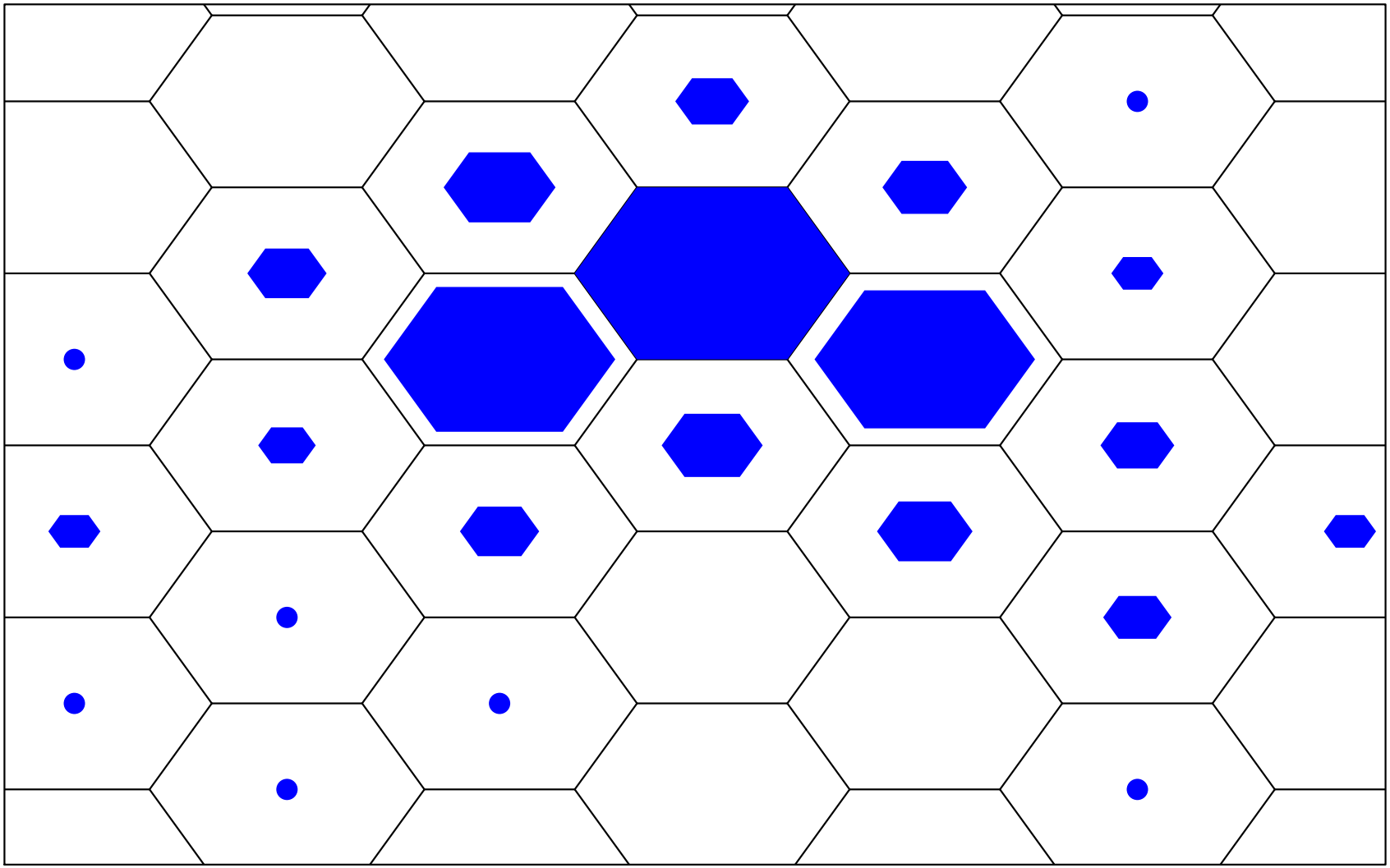
# Hexagonal binning

Binning in two dimensions;



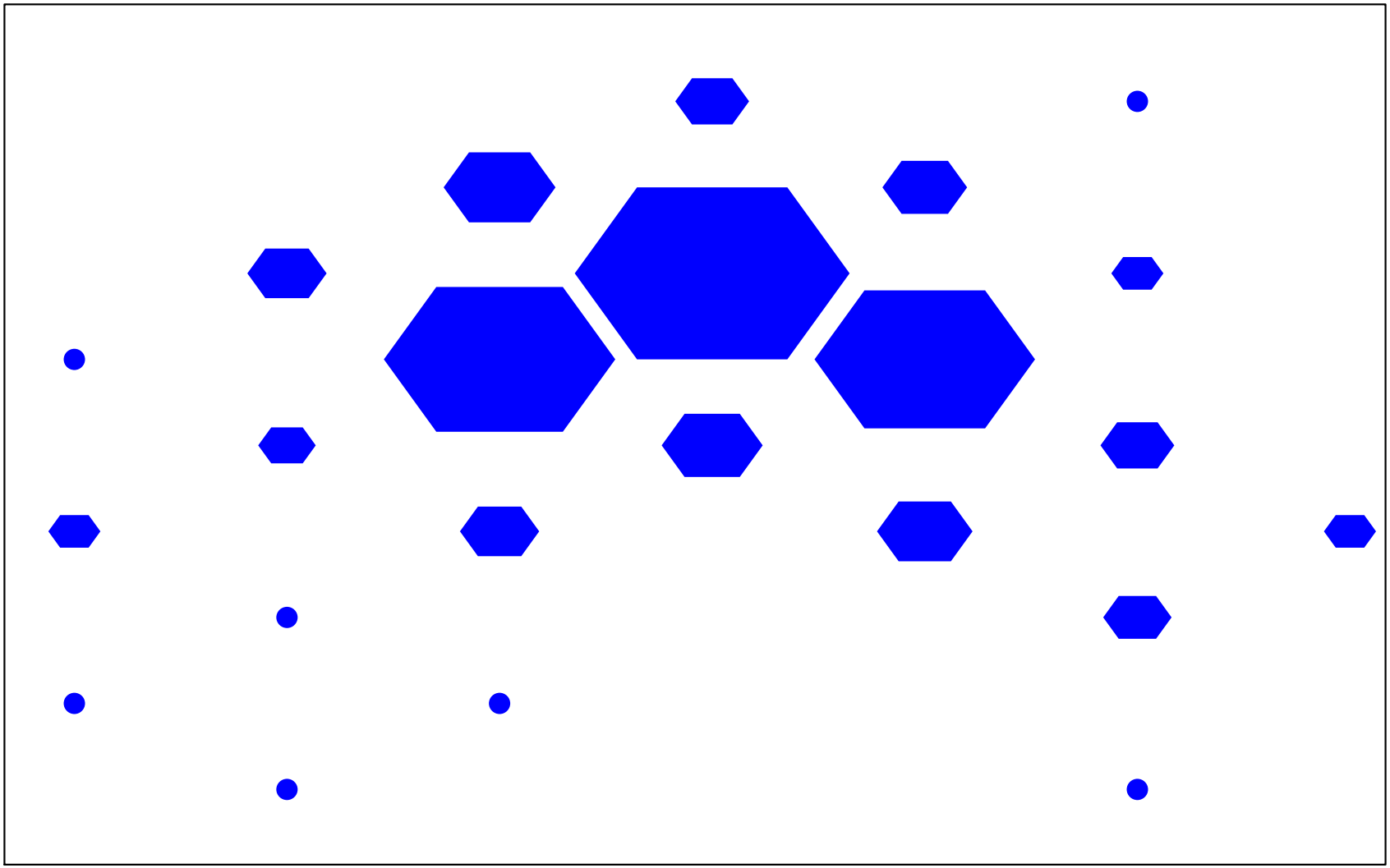
# Hexagonal binning

Binning in two dimensions;



# Hexagonal binning

Binning in two dimensions;

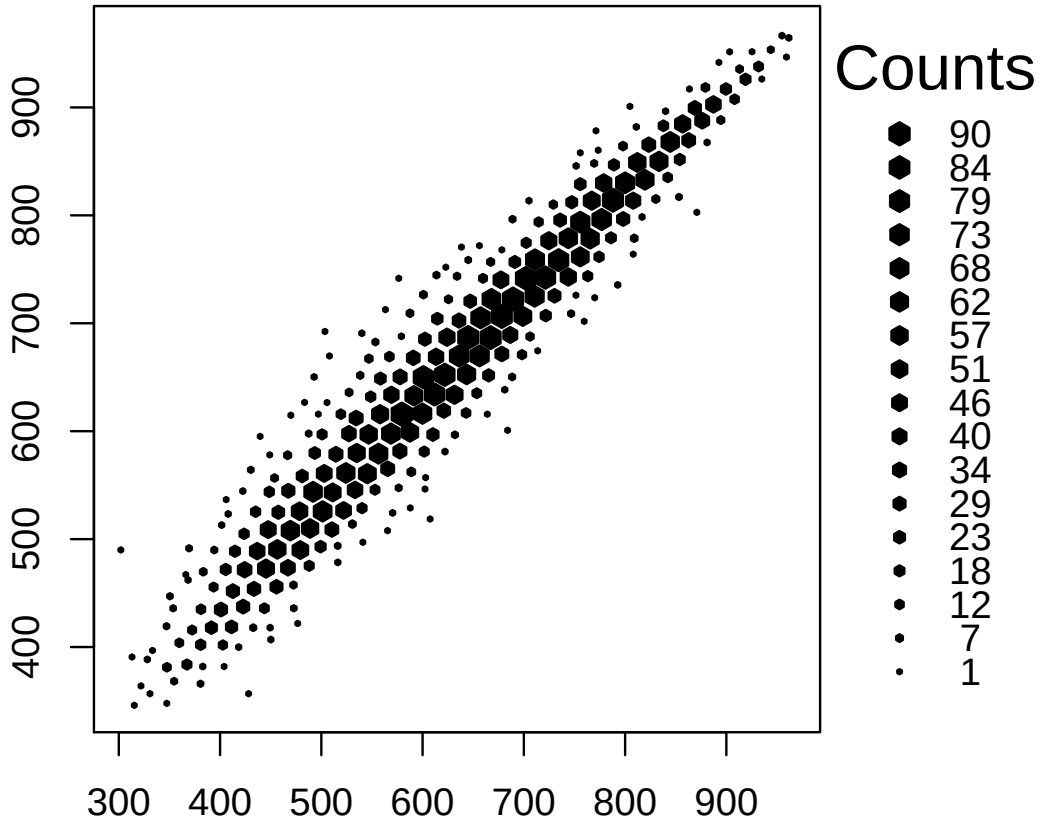


# Hexagonal binning

The `hexbin()` package does all the bin construction, and counting. It has a `plot` method for its `hexbin` objects;

```
install.packages(c("hexbin","survey"))
library("hexbin")
library("survey")# for apipop data frame

with(apipop, plot(hexbin(api99,api00), style="centroids"))
```

# Hexagonal binning



# Hexagonal binning

Hexbins are useful when you don't *really* care about the exact location of every single point;

- Singleton points are plotted 'as usual'; you do (perhaps) care about them
- `hexbin` centers the 'ink' at the cell data's 'center of gravity'
- `style="centroids"` gives the center-of-gravity version; the default `style` is `colorscale` – usually grayscale. See `?gplot.hexagons` for more options

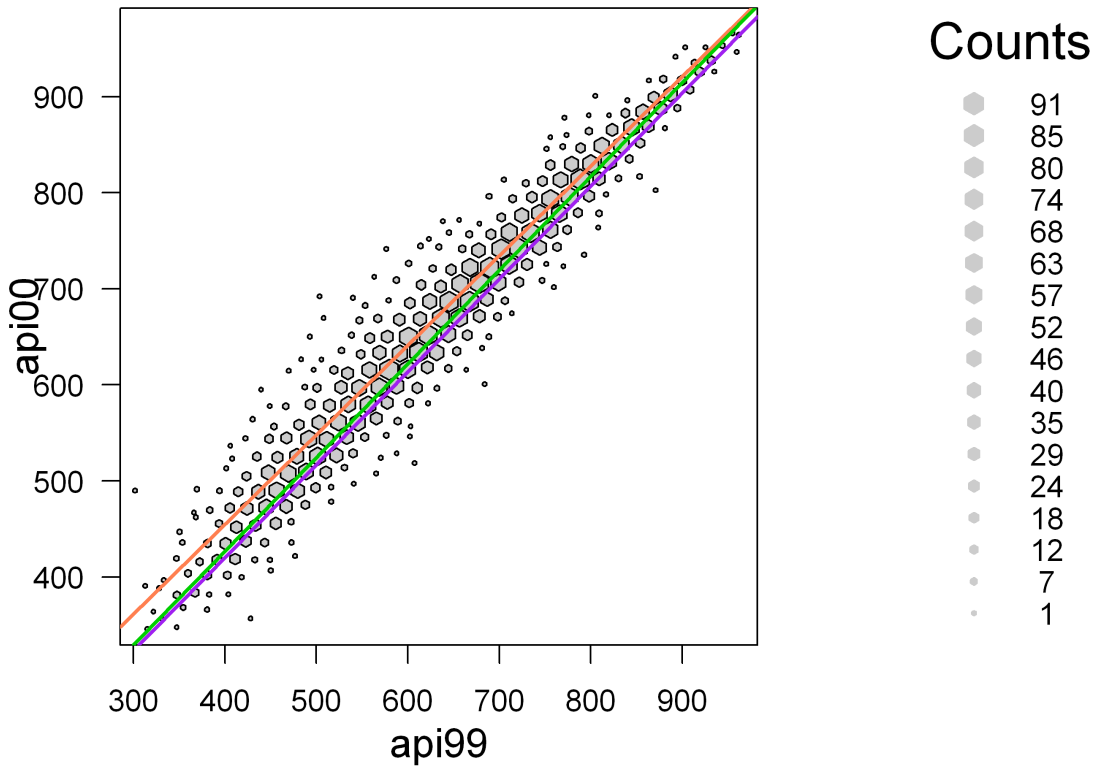
# Hexagonal binning

For keen people: the `hexbin` package doesn't use the standard R graphics plotting devices; instead, it operates through the `Grid` system (in the `grid` package) which defines rectangular regions on a graphics device; these `viewport` regions can have a number of coordinate systems. To add lines to a hexbin plot, the options are;

- Use `hexVP.abline()` to add these directly
- Move everything into 'standard' graphics – not `Grid` graphics (see `?Grid`). The `Grid` system lets you alter graphics *after* plotting them
- Write your own plot method for hexbin objects, with standard R graphics commands
- Make do with `hexBinning()` in the `fMultivar` package

# Hexagonal binning

An example; color-coded lines of best fit, by school type;




```
lm.e <- coef(lm(api00~api99, data=apipop, subset=stype=="E"))
lm.m <- coef(lm(api00~api99, data=apipop, subset=stype=="M"))
lm.h <- coef(lm(api00~api99, data=apipop, subset=stype=="H"))

hexVP.abline(vp1$plot.vp, lm.e[1], lm.e[2], col="coral")
```

# Large data: multiple groups

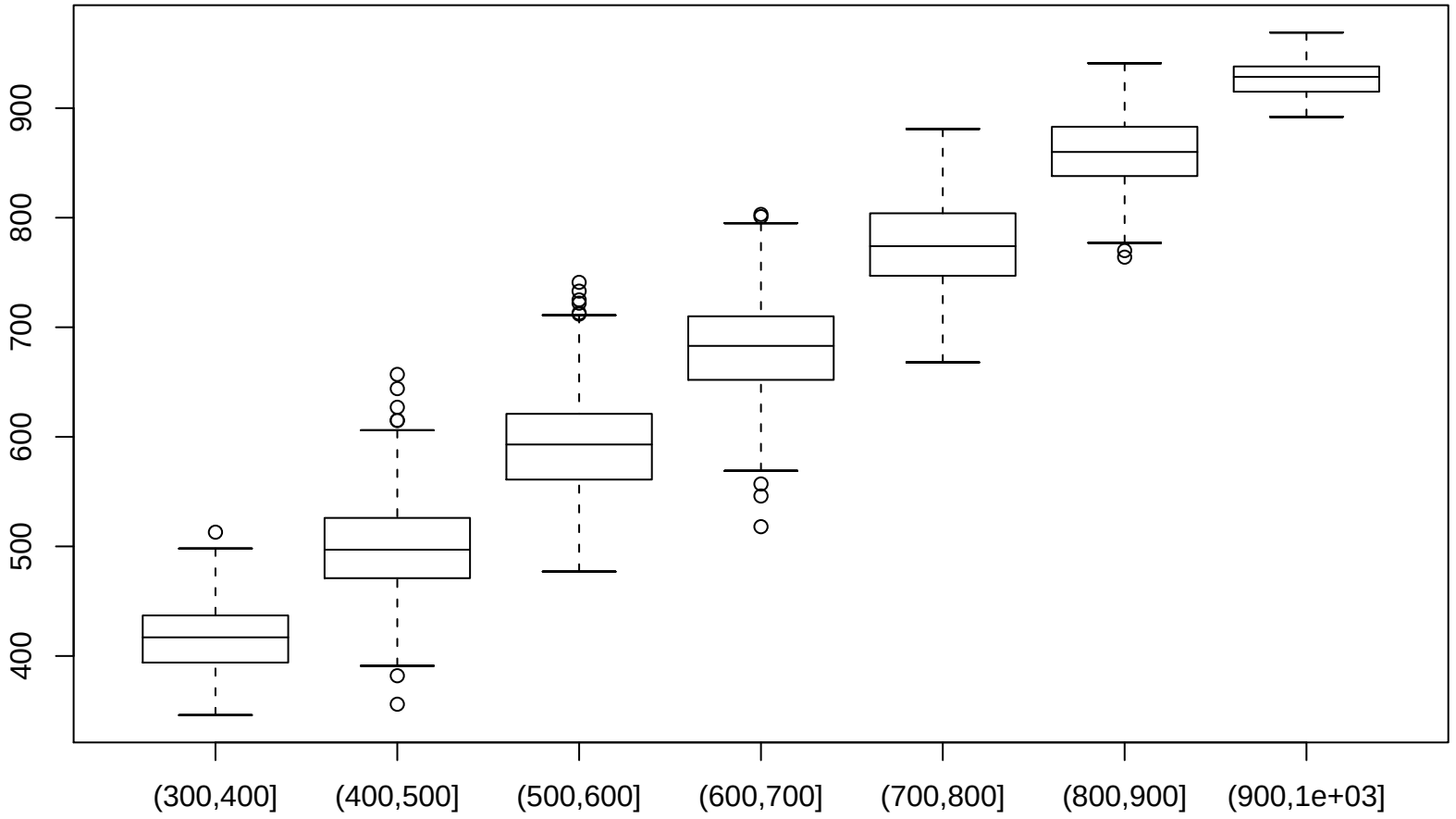
For showing multiple groups, a scatterplot smoother or perhaps boxplots or conditioning may be better.

```
boxplot(api00~cut(api99,(3:10)*100), data=apipop)
par(las=1)
par(mar=c(5.1,10.1,2.1,2.1))
boxplot(api00~interaction(stype,
                          cut(api99,(3:10)*100)),
        data=apipop, horizontal=TRUE,col=1:3)
```

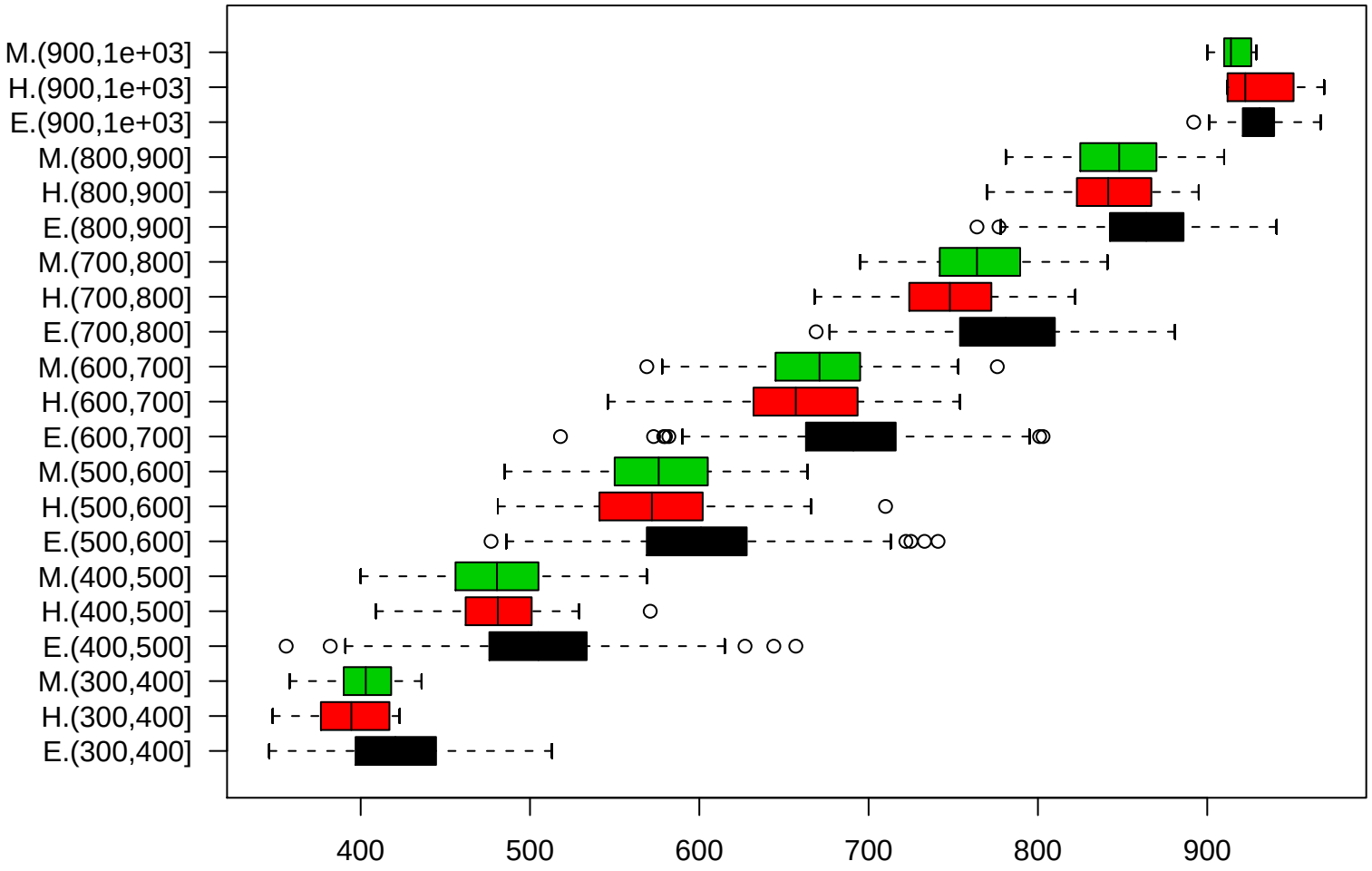
- `cut()` turns a variable into a factor by cutting it at the specified points.

- `par(mar=)` sets the margins around the plot. We need a large left margin for the labels.

# Large data: multiple groups



# Large data: multiple groups



# Smoothers

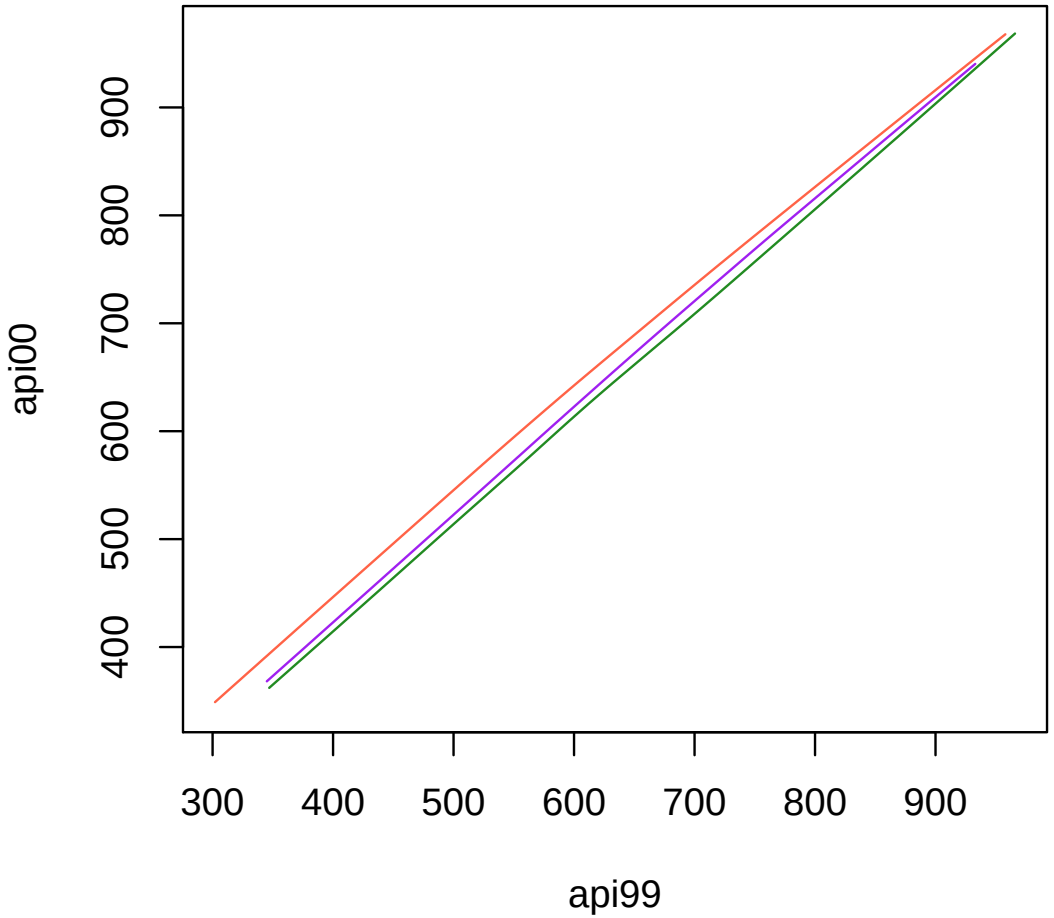
We don't plot the data at all, just means (could also plot quantiles with `quantreg` package)

```
plot(api00~api99,data=apipop,type="n")
with(subset(apipop, stype=="E"),
     lines(lowess(api99, api00), col="tomato"))
with(subset(apipop, stype=="H"),
     lines(lowess(api99, api00), col="forestgreen"))
with(subset(apipop, stype=="M"),
     lines(lowess(api99, api00), col="purple"))
```

Note the use of `type="n"`

`subset()` returns a subset of a data frame.

# Smoothers



# Conditioning

```
hexbinplot(api00~api99|stype,data=apipop,style="centroid")
```