



**Barcelona  
Supercomputing  
Center**  
*Centro Nacional de Supercomputación*



## 8. Color y Precisión Visual

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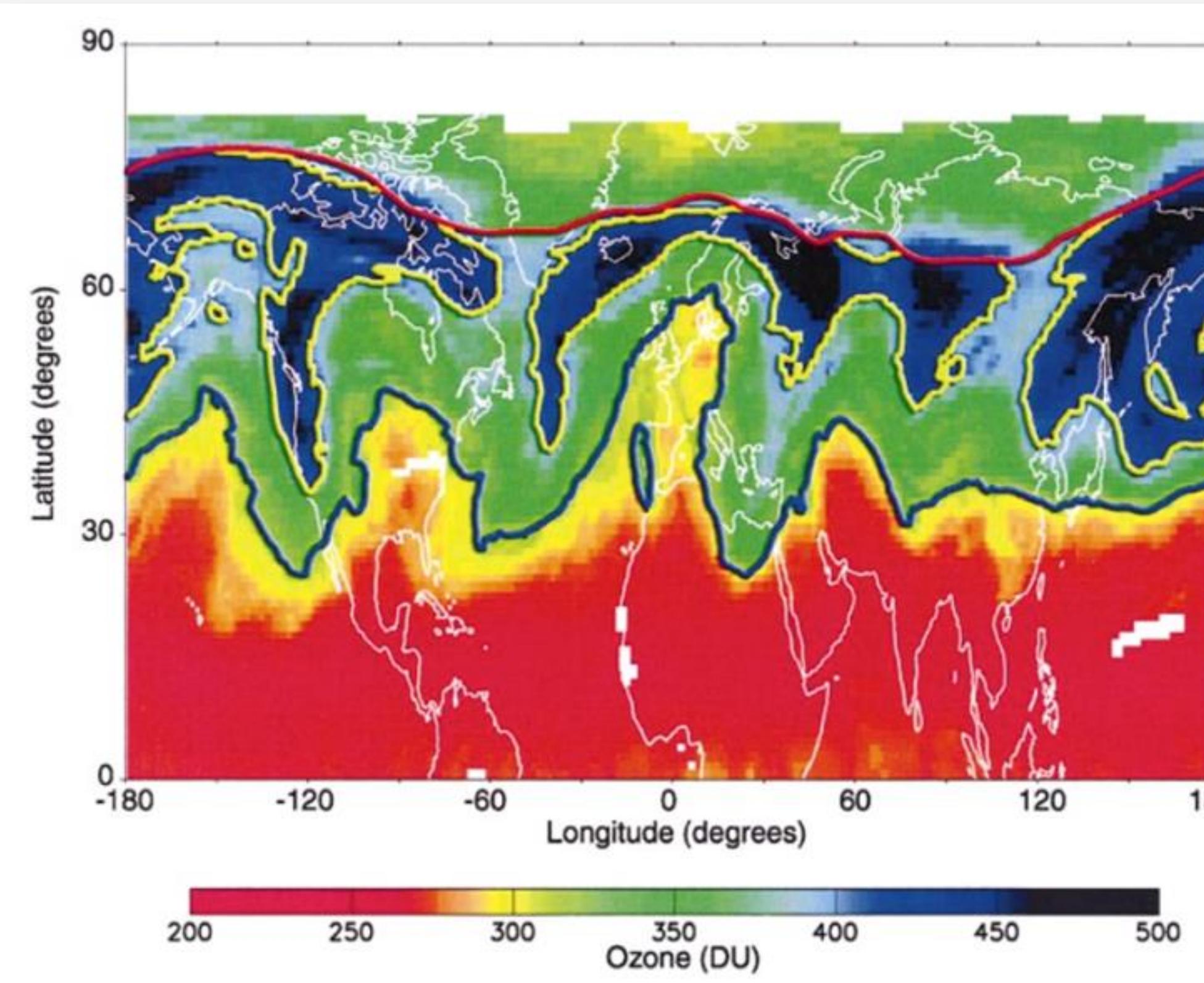
**UAB**  
Universitat Autònoma  
de Barcelona

8.1

C O I O R

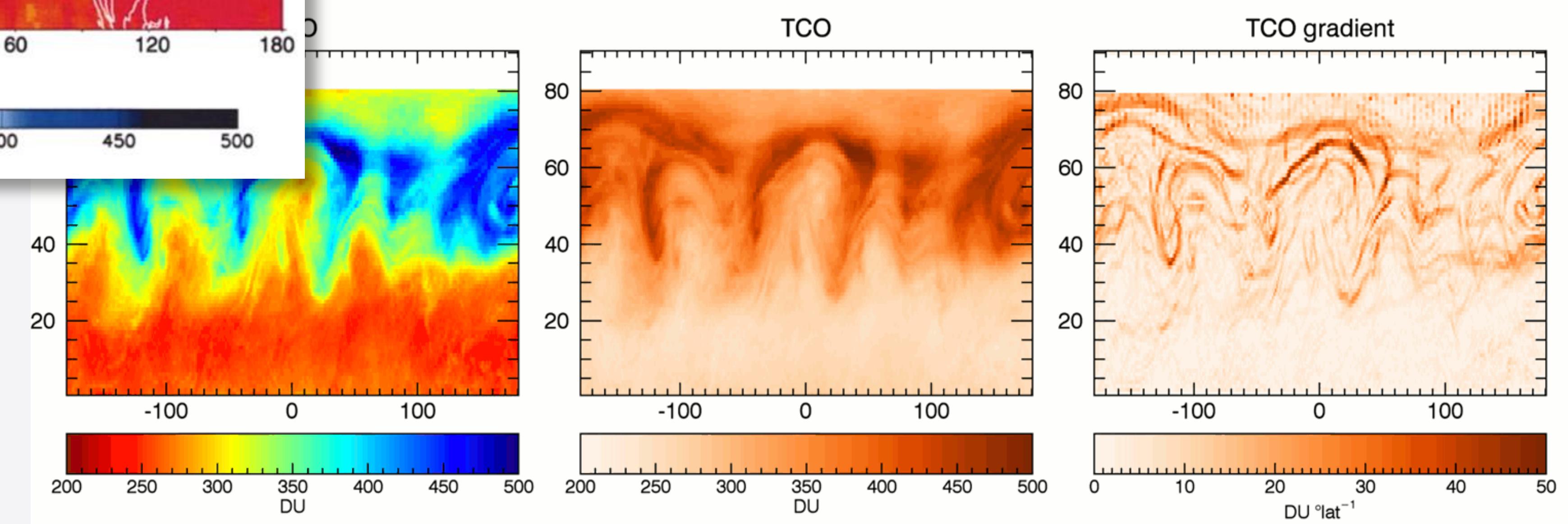
The word 'COIOR' is rendered in a large, bold, sans-serif font. Each letter is defined by multiple concentric circles of varying sizes and two vertical rectangles on either side. The primary colors used are teal and pink, creating a layered, 3D effect. The 'C' has a teal outer ring and a pink inner ring. The 'O' has a pink outer ring and a teal inner ring. The 'I' consists of two vertical rectangles, one teal on the left and one pink on the right. The 'O' and 'R' also have additional teal and pink rings respectively, contributing to their complex, geometric appearance.

# BEWARE OF THE RAINBOW



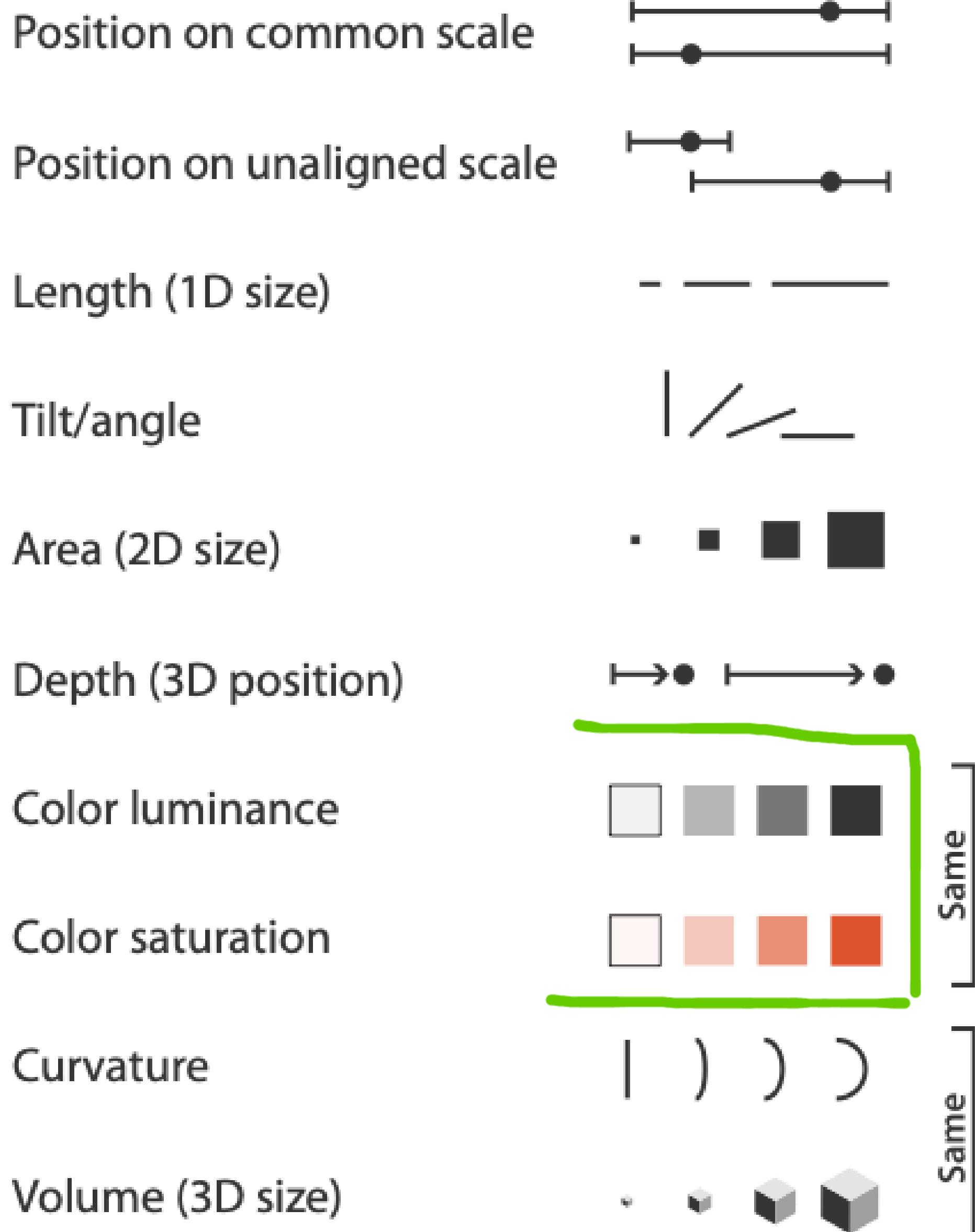
Hudson, R. D., Andrade, M. F., Follette, M. B., and Frolov, A. D.:

The total ozone field separated into meteorological regimes – Part II: Northern Hemisphere mid-latitude total ozone trends,  
Atmos. Chem. Phys., 6, 5183-5191, <https://doi.org/10.5194/acp-6-5183-2006>, 2006.

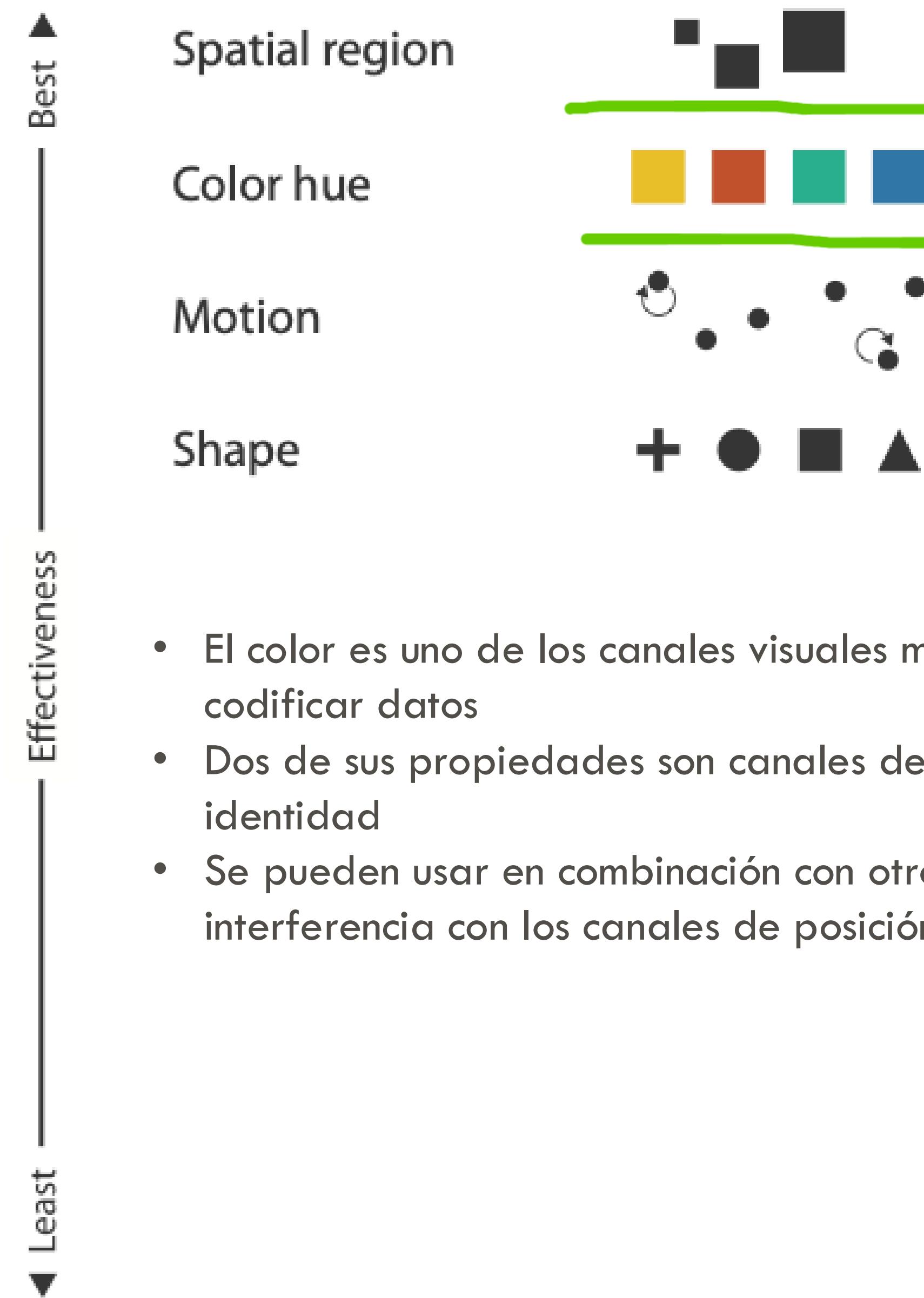


The wrong color palette can  
show effects in the visualization  
not present in the data

## → Magnitude Channels: Ordered Attributes



## → Identity Channels: Categorical Attributes



- El color es uno de los canales visuales más potentes para codificar datos
- Dos de sus propiedades son canales de magnitud y una de identidad
- Se pueden usar en combinación con otros: tienen poca o ninguna interferencia con los canales de posición

# R cheatsheet

## R color cheatsheet

Finding a good color scheme for presenting data can be challenging. This color cheatsheet will help!

### R uses hexadecimal to represent colors

Hexadecimal is a base-16 number system used to describe color. Red, green, and blue are each represented by two characters (#rrggb). Each character has 16 possible symbols: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F:

"00" can be interpreted as 0.0 and "FF" as 1.0 i.e., red = #FF0000, black = #000000, white = #FFFFFF

Two additional characters (with the same scale) can be added to the end to describe transparency (#rrggbba)

### R has 657 built in color names

Example: To see a list of names: colors()

These colors are displayed on P. 3.

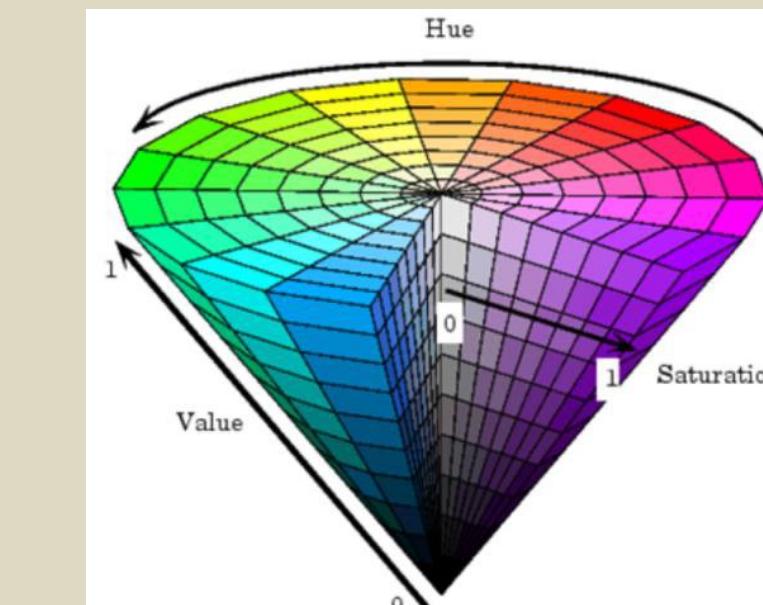
### R translates various color models to hex, e.g.:

- RGB (red, green, blue): The default intensity scale in R ranges from 0-1; but another commonly used scale is 0-255. This is obtained in R using maxColorValue=255. alpha is an optional argument for transparency, with the same intensity scale.  
`rgb(r, g, b, maxColorValue=255, alpha=255)`
- HSV (hue, saturation, value): values range from 0-1, with optional alpha argument  
`hsv(h, s, v, alpha)`
- HCL (hue, chroma, luminance): hue describes the color and ranges from 0-360; 0 = red, 120 = green, blue = 240, etc. Range of chroma and luminance depend on hue and each other  
`hcl(h, c, l, alpha)`

### A few notes on HSV/HLC

HSV is a better model for how humans perceive color. HCL can be thought of as a perceptually based version of the HSV model....blah blah blah...

Without delving into color theory: color schemes based on HSV/HLC models generally just look good.



R can translate colors to rgb (this is handy for matching colors in other programs)  
`col2rgb(c("#FF0000", "blue"))`

### R Color Palettes

This is for all of you who don't know anything about color theory, and don't care but want some nice colors on your map or figure....NOW!

TIP: When it comes to selecting a color palette, DO NOT try to handpick individual colors! You will waste a lot of time and the result will probably not be all that great. R has some good packages for color palettes. Here are some of the options

#### Packages: grDevices and colorRamps

grDevices comes with the base installation and colorRamps must be installed. Each palette's function has an argument for the number of colors and transparency (*alpha*):

`heat.colors(4, alpha=1)`

> "#FF0000FF" "#FF8000FF" "#FFFF00FF" "#FFF800FF"

For the rainbow palette you can also select start/end color (red = 0, yellow = 1/6, green = 2/6, cyan = 3/6, blue = 4/6 and magenta = 5/6) and saturation (s) and value (v):  
`rainbow(n, s = 1, v = 1, start = 0, end = max(1, n - 1)/n, alpha = 1)`

grDevices palettes cm.colors topo.colors terrain.colors heat.colors rainbow  
see P. 4 for options

#### Package: RcolorBrewer

This function has an argument for the number of colors and the color palette (see P. 4 for options).  
`brewer.pal(4, "Set3")`

> "#8DD3C7" "#FFFFB3" "#BEBADA" "#FB8072"

To view colorbrewer palettes in R: `display.brewer.all(5)`  
There is also a very nice interactive viewer:  
<http://colorbrewer2.org/>

### ## My Recommendation ##

#### Package: colorspace

These color palettes are based on HCL and HSV color models. The results can be very aesthetically pleasing. There are some default palettes:

`rainbow_hcl(4)`

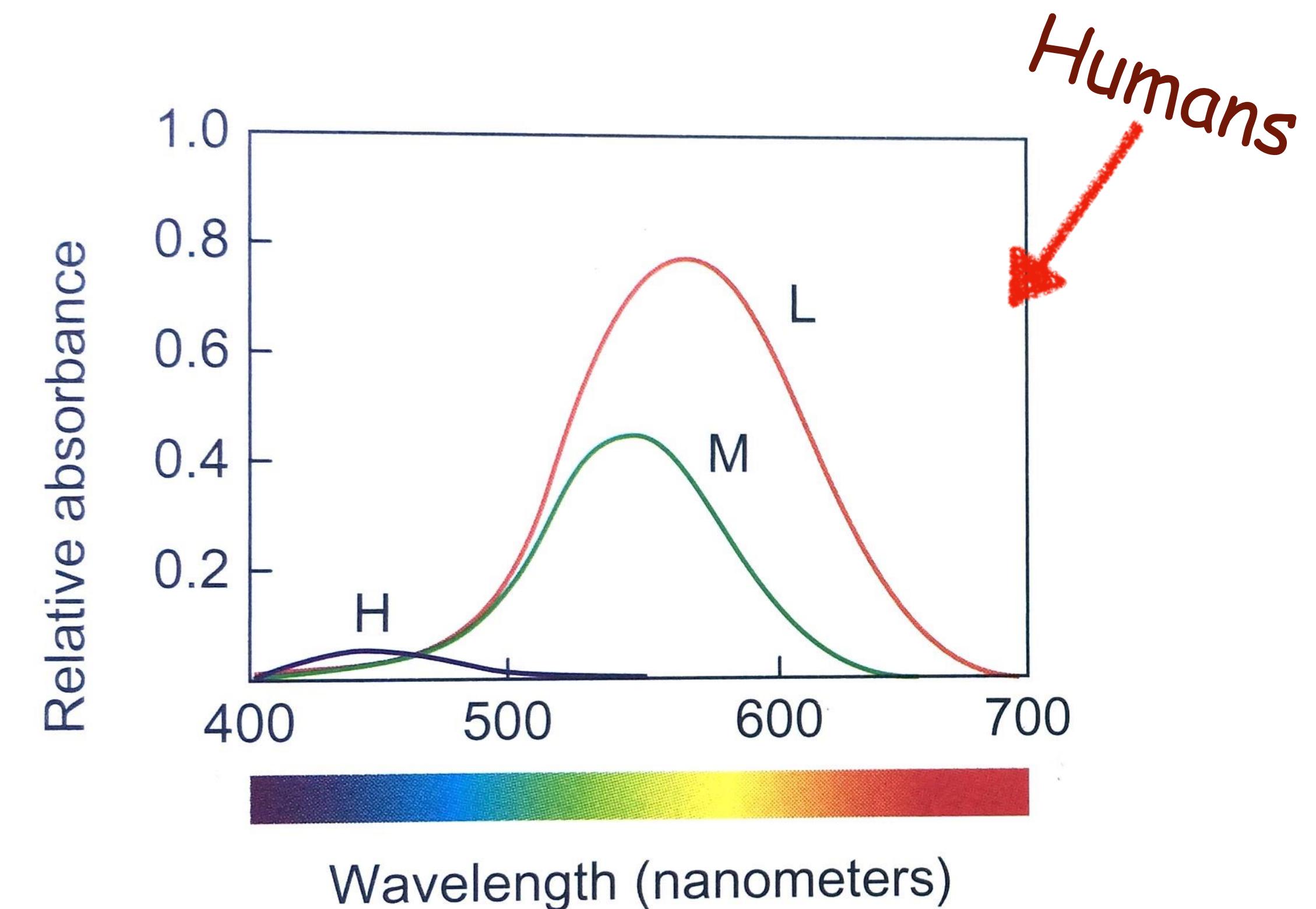
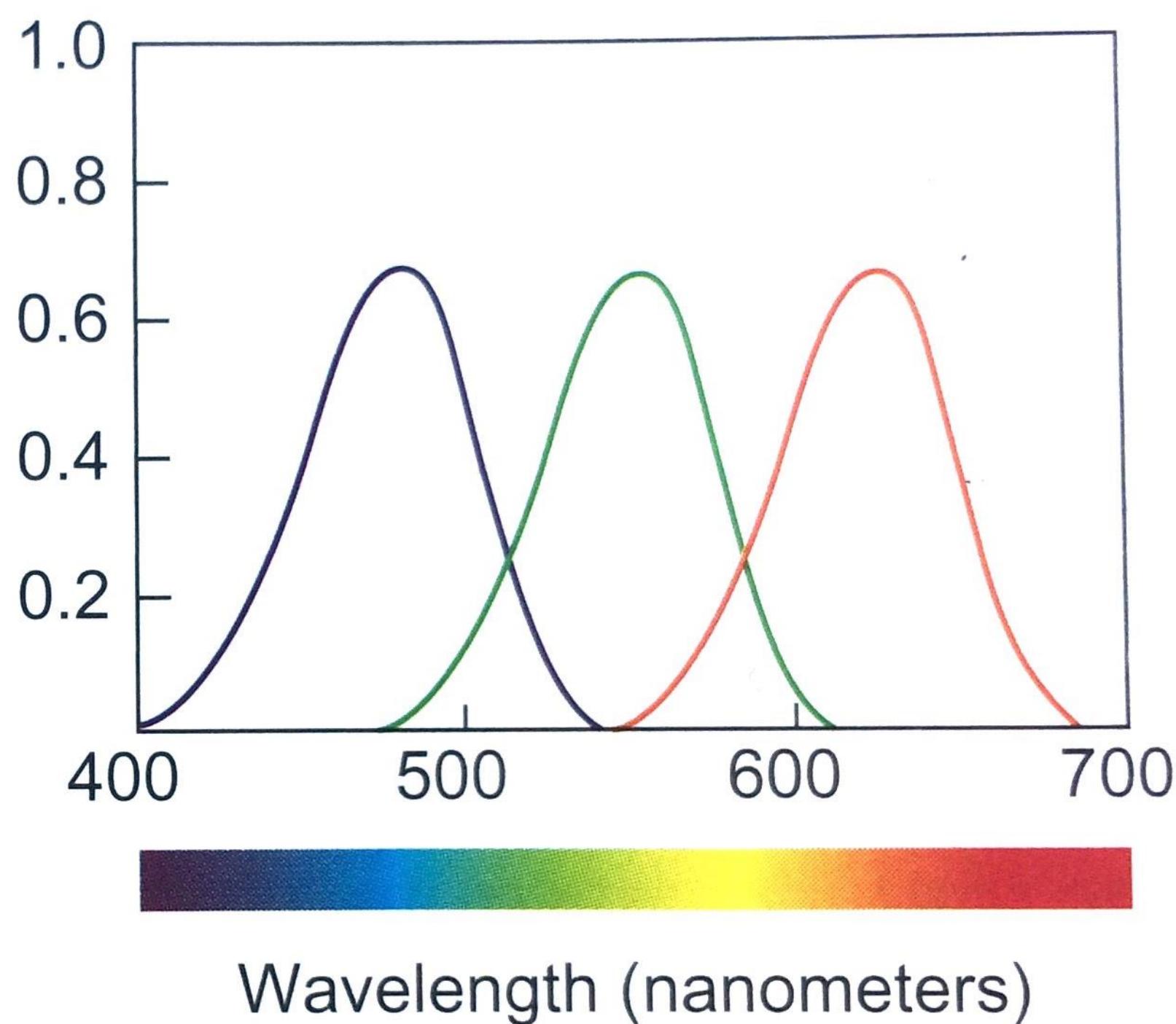
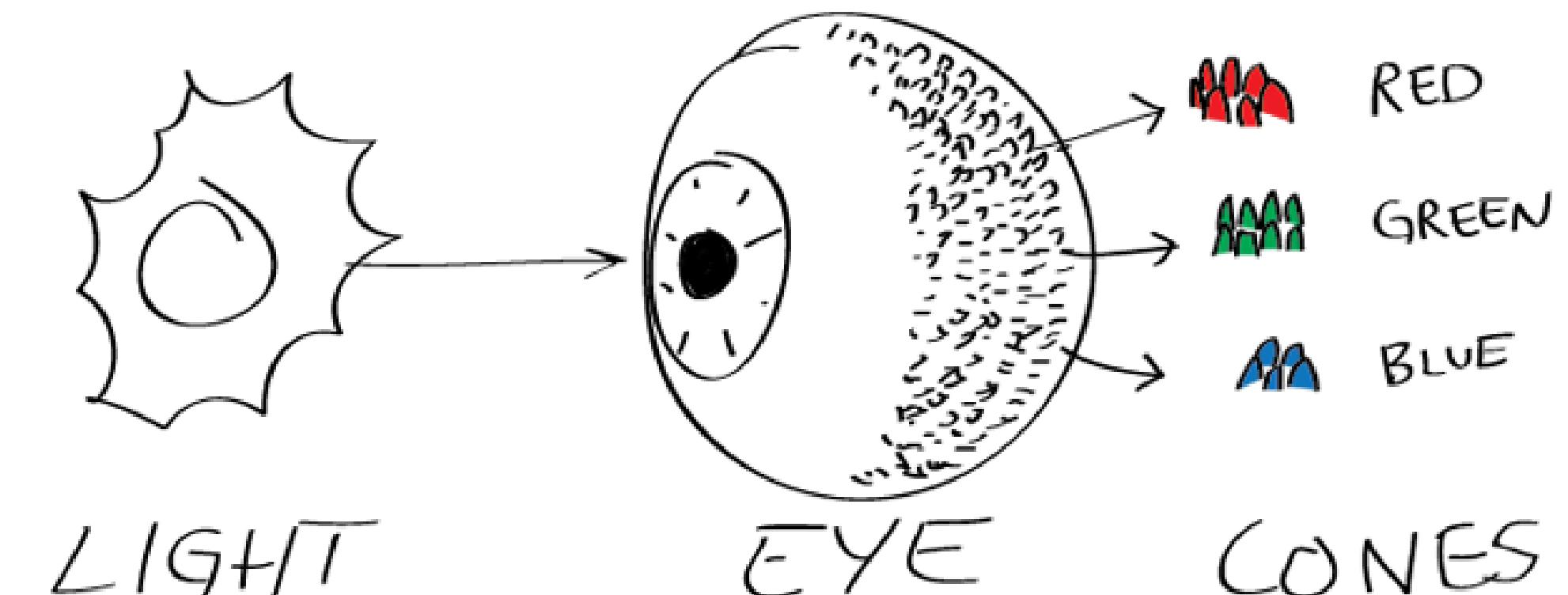
> "#E495A5" "#ABB065" "#39BEB1" "#ACA4E2"

colorspace default palettes diverge\_hcl diverge\_hsl terrain\_hcl sequential\_hcl rainbow\_hcl

However, all palettes are fully customizable:  
`diverge_hcl(7, h = c(246, 40), c = 96, l = c(65, 90))`  
Choosing the values would be daunting. But there are some recommended palettes in the colorspace documentation. There is also an interactive tool that can be used to obtain a customized palette. To start the tool:  
`pal <- choose_palette()`

# Percepción

- Tenemos tres tipos de conos que reaccionan a espectros distintos y de forma desigual
- No son como receptores de una cámara, frecuencias más largas generan estímulos más fuertes

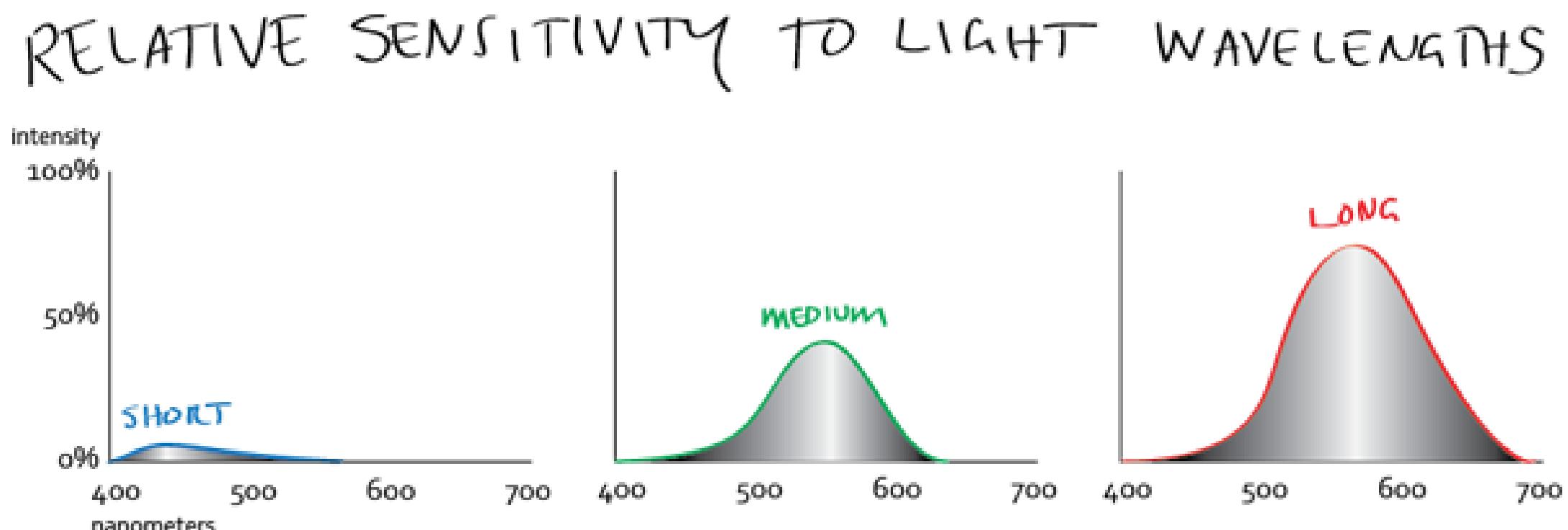
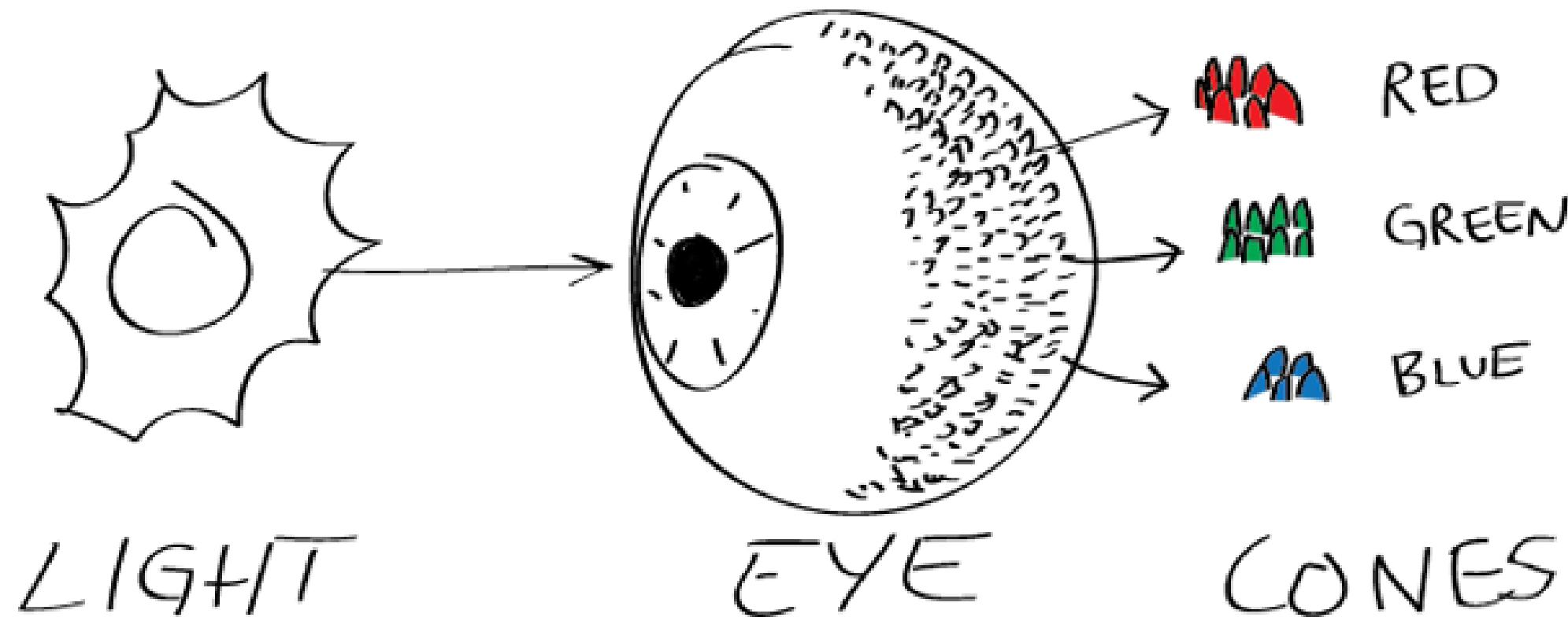


# Opponent Process

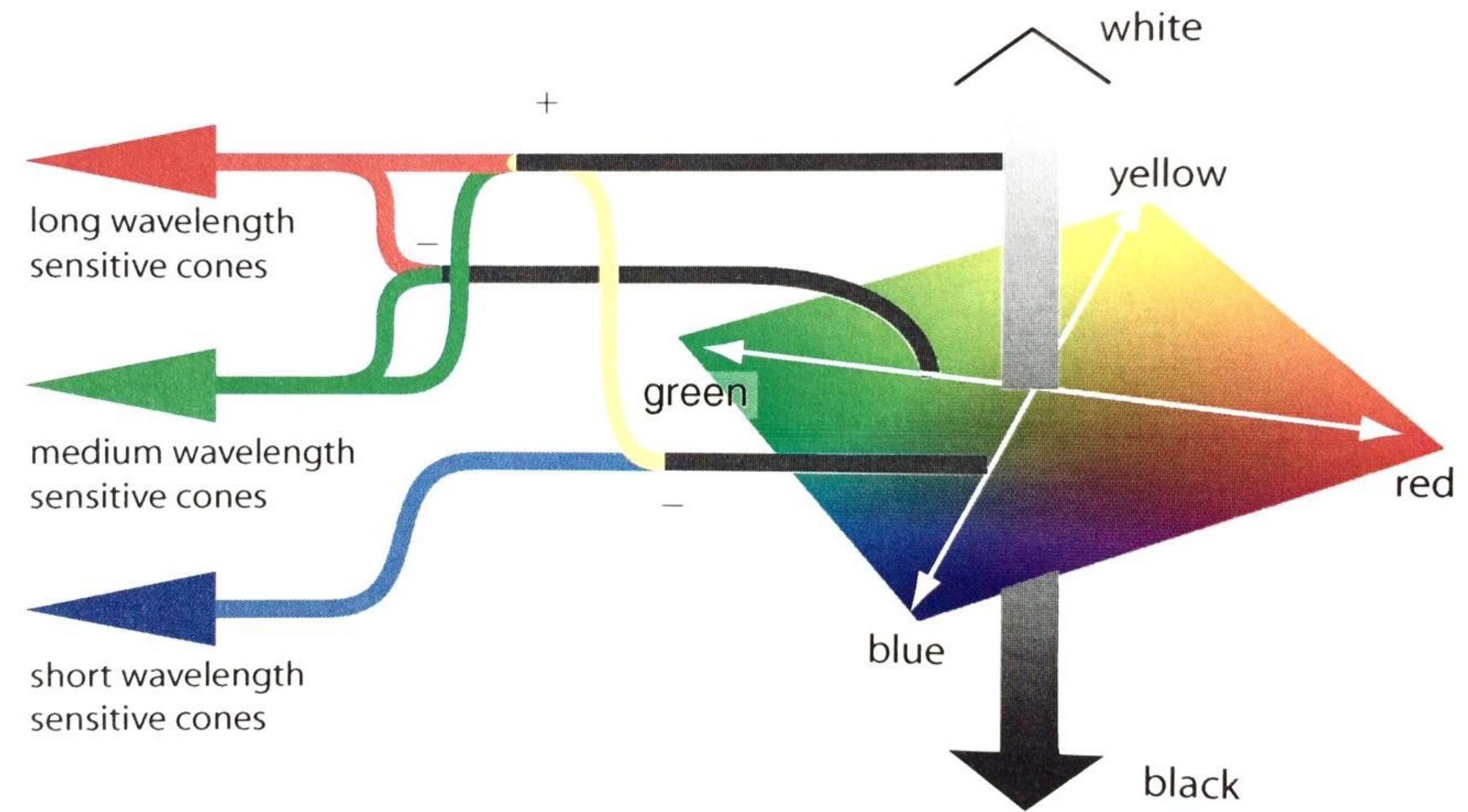
## Theory of Color

Ewald Hering, 1920

- The brain combines the signals by subtraction: receptors subtract med. and long freq. making a red-green-difference signal channel.
- Other neurones subtract long and short yielding yellow-blue-diff signal channel;
- Third group of neurones ADD long and medium to create luminance (B&W) channel



difference signal channels



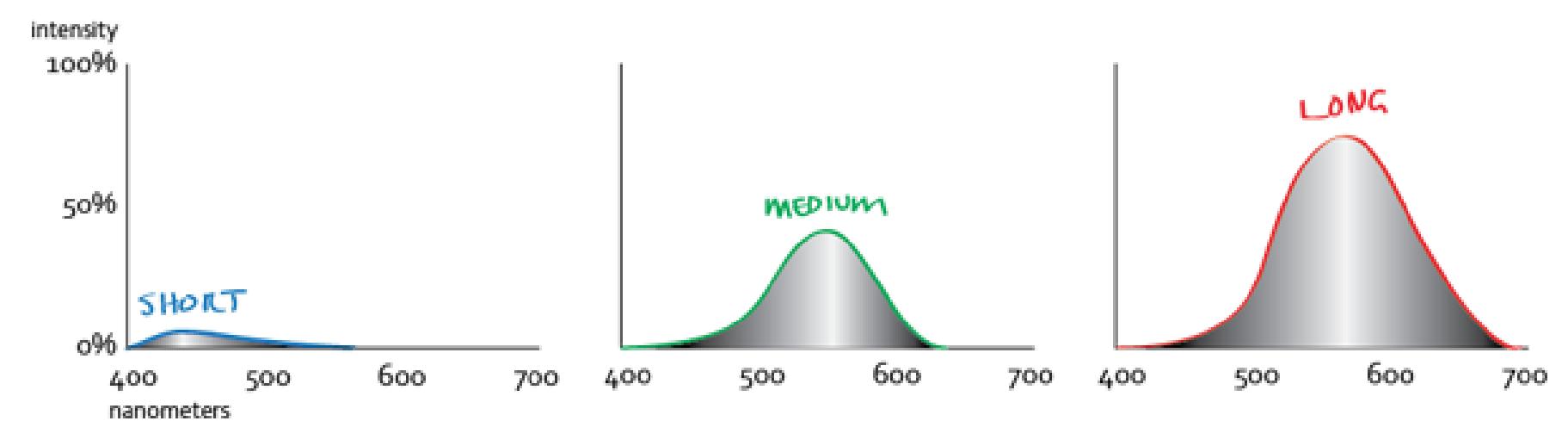
Ware, 2008

# Opponent Process

## Theory of Color

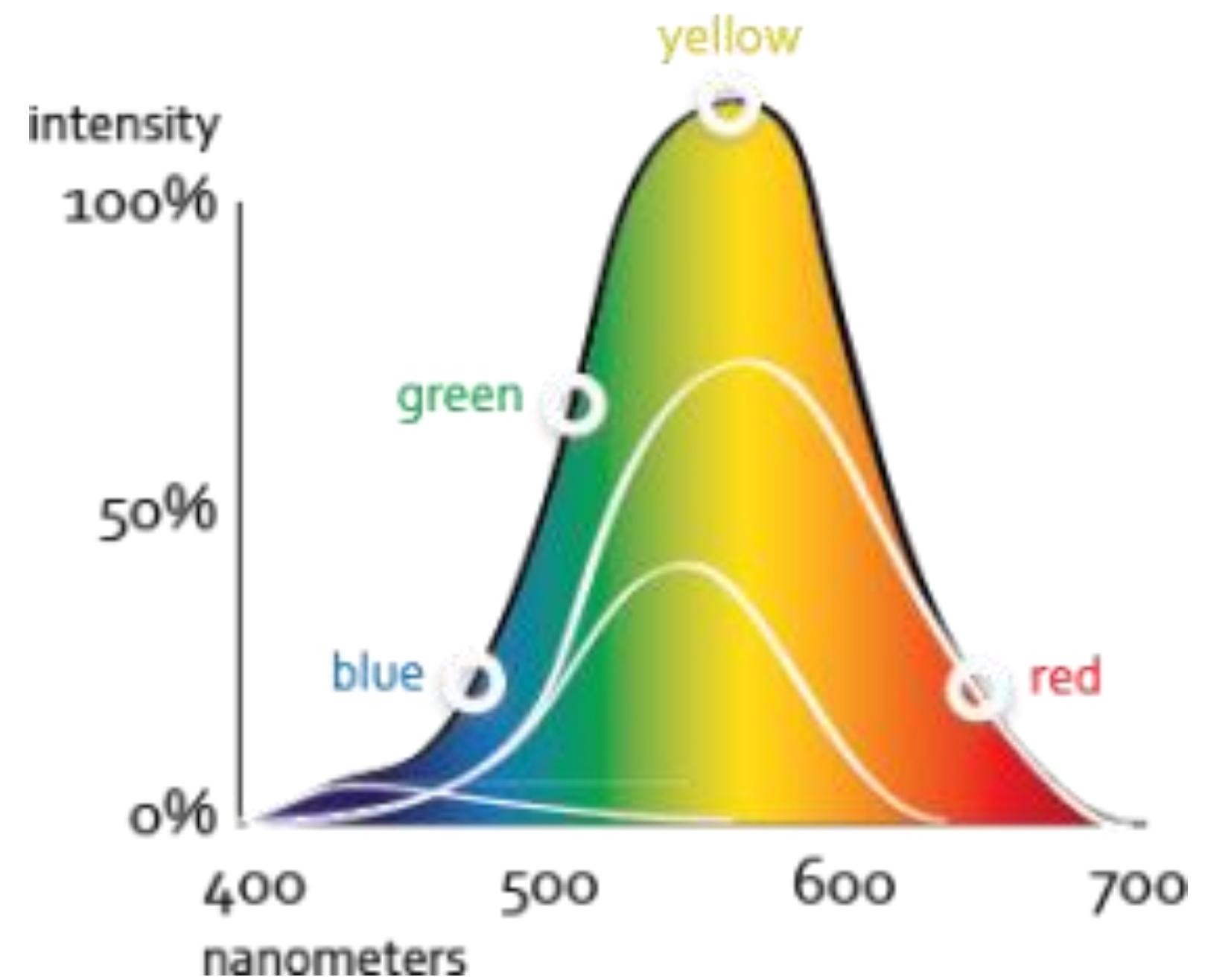
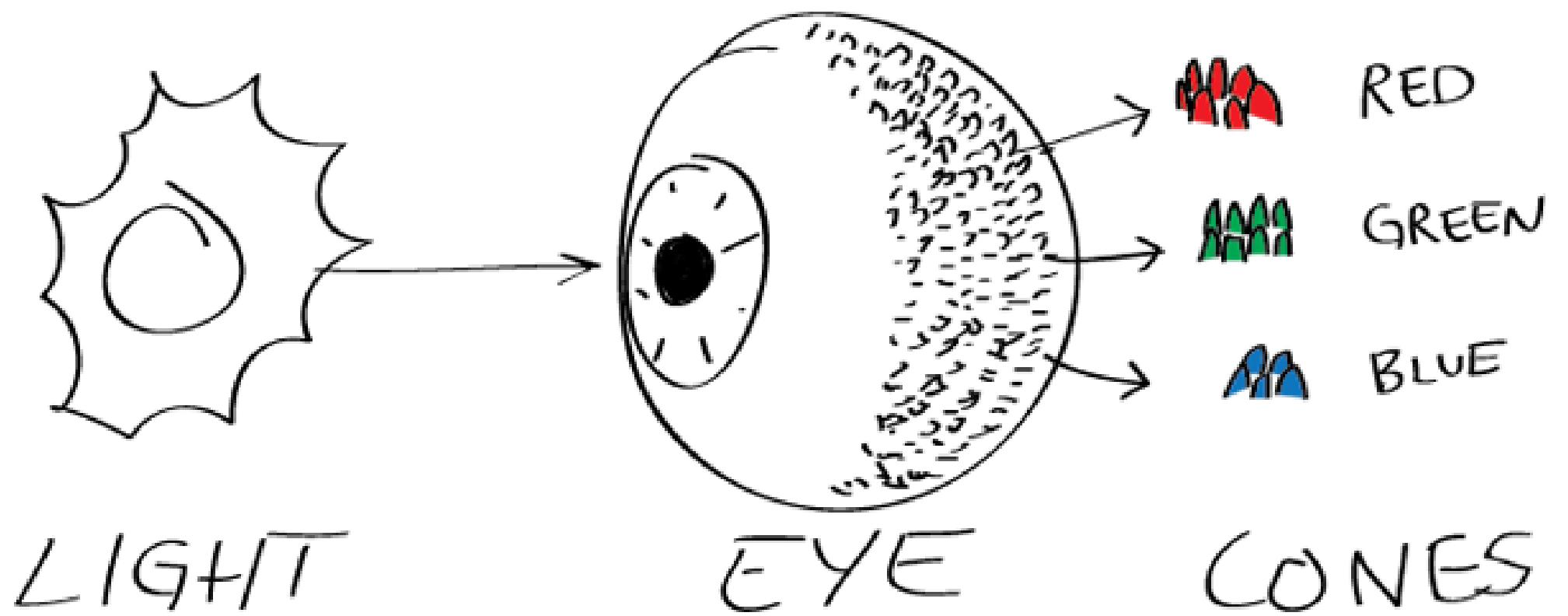
Ewald Hering, 1920

### RELATIVE SENSITIVITY TO LIGHT WAVELENGTHS



- Cuando vemos Amarillo hay una sobre excitación de muchos receptores que hacen que lo percibamos más intensamente que otros colores

PUTTING IT ALL TOGETHER

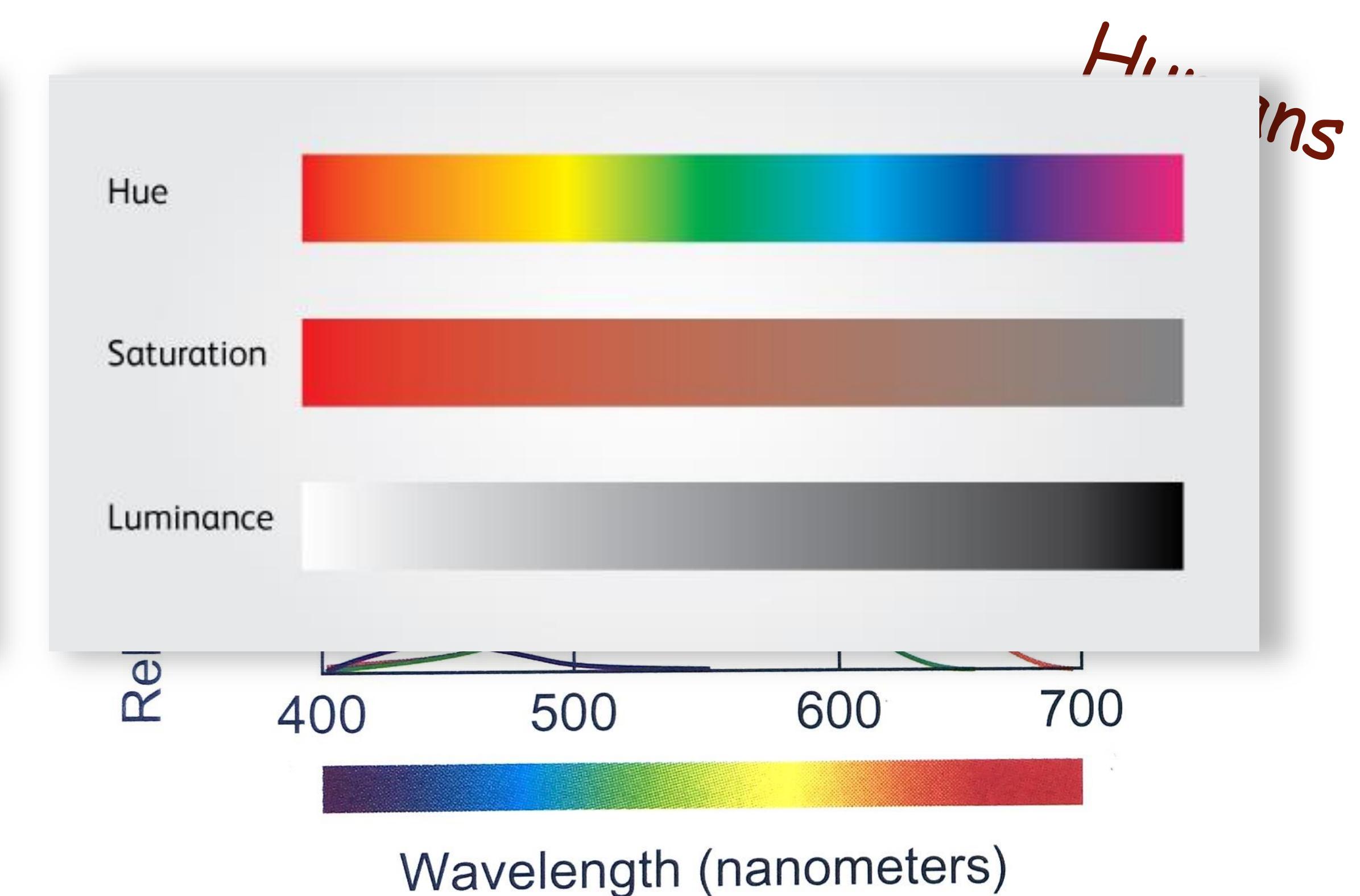
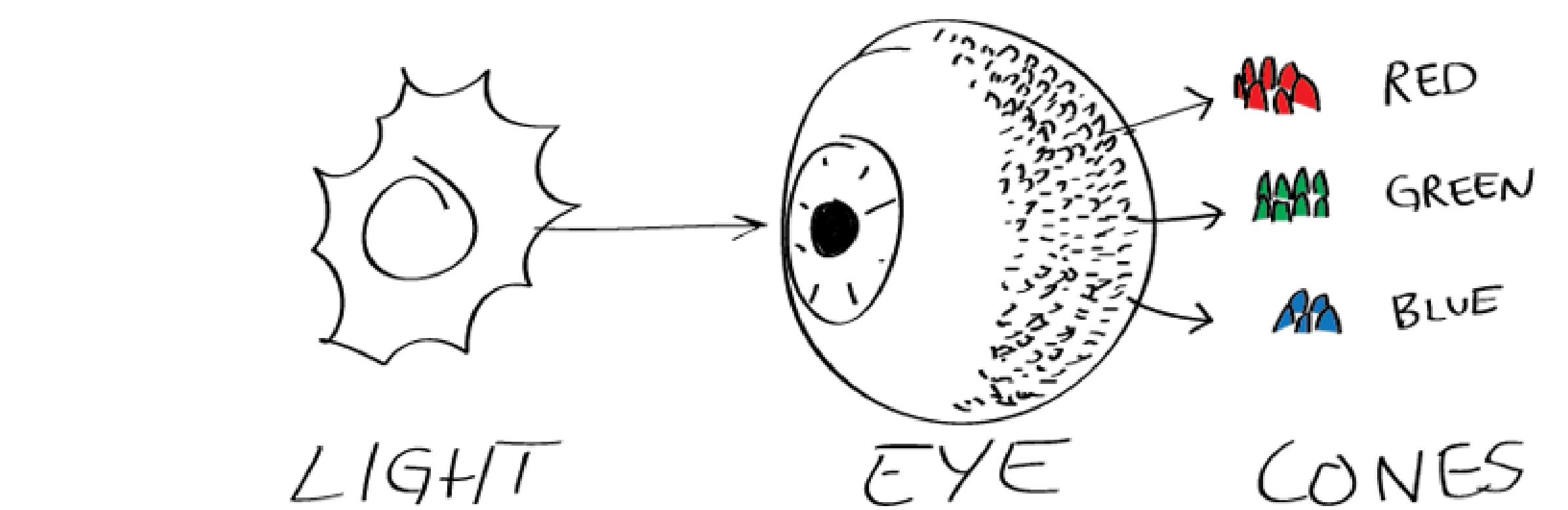
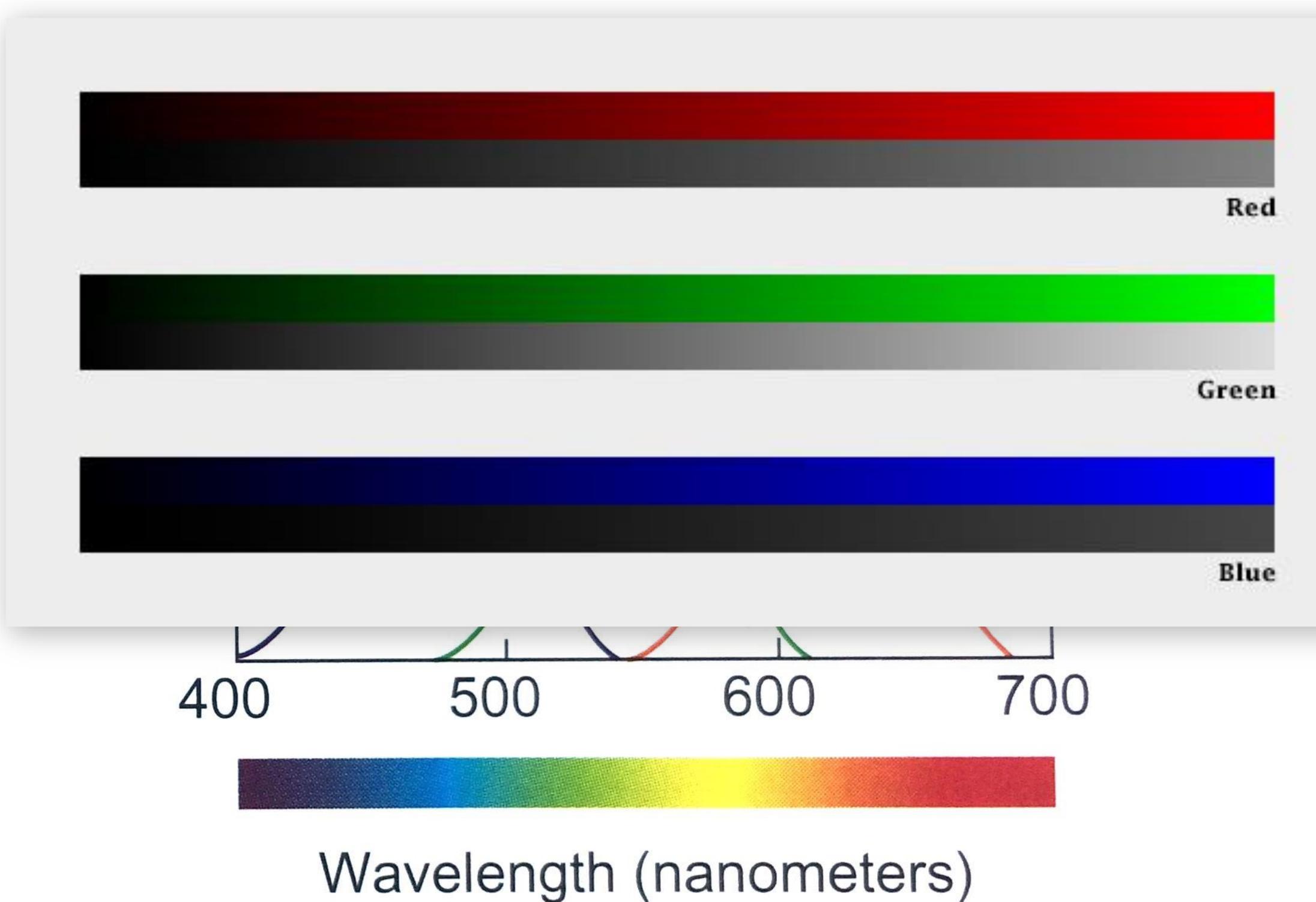


# Percepción

Computers process a combination of very narrow frequency bands of red, green, and blue

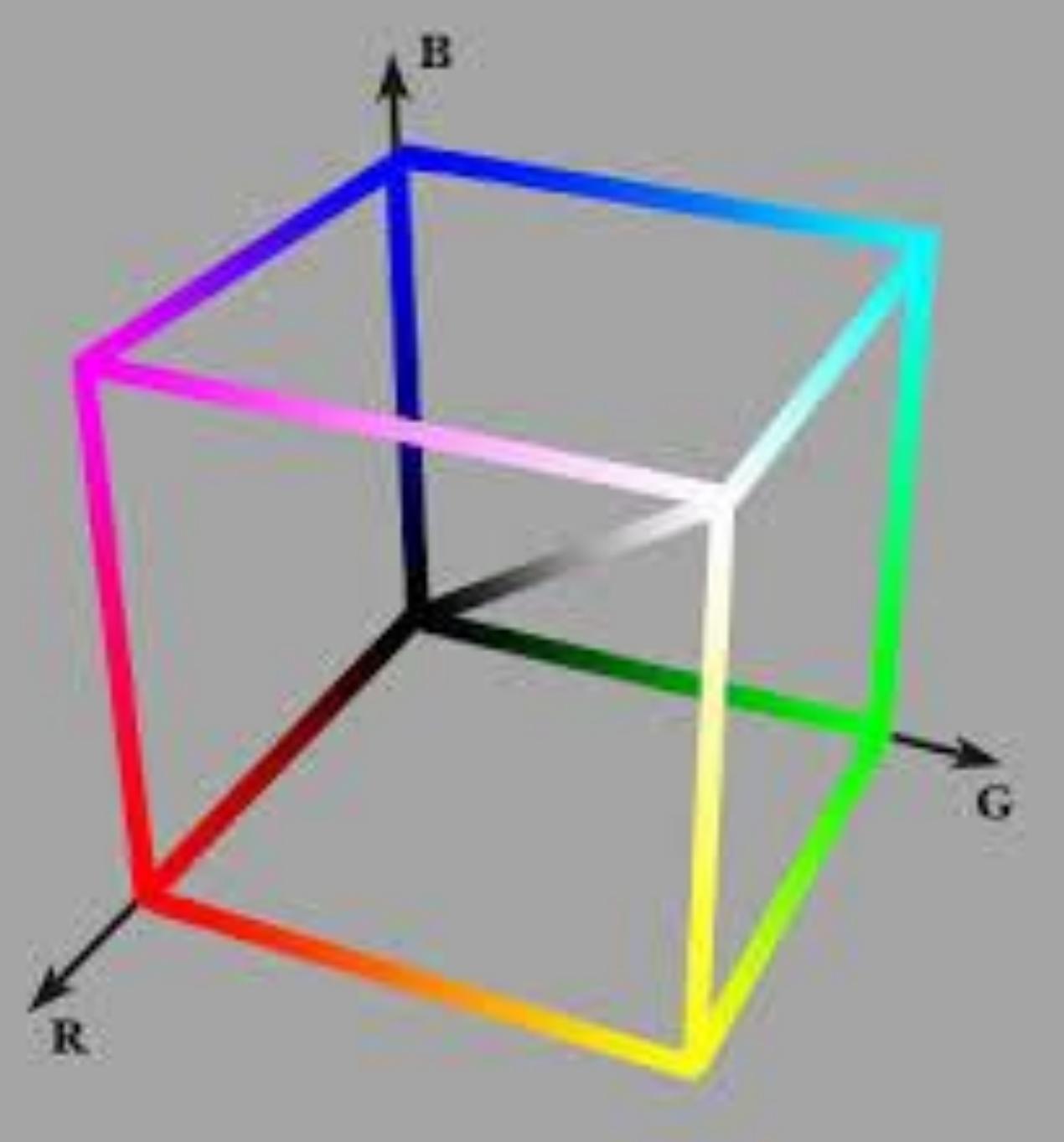
Computers calculate light linearly

Our eyes detect red, green, and blue light but we think about colour in terms of lightness, hue, and saturation

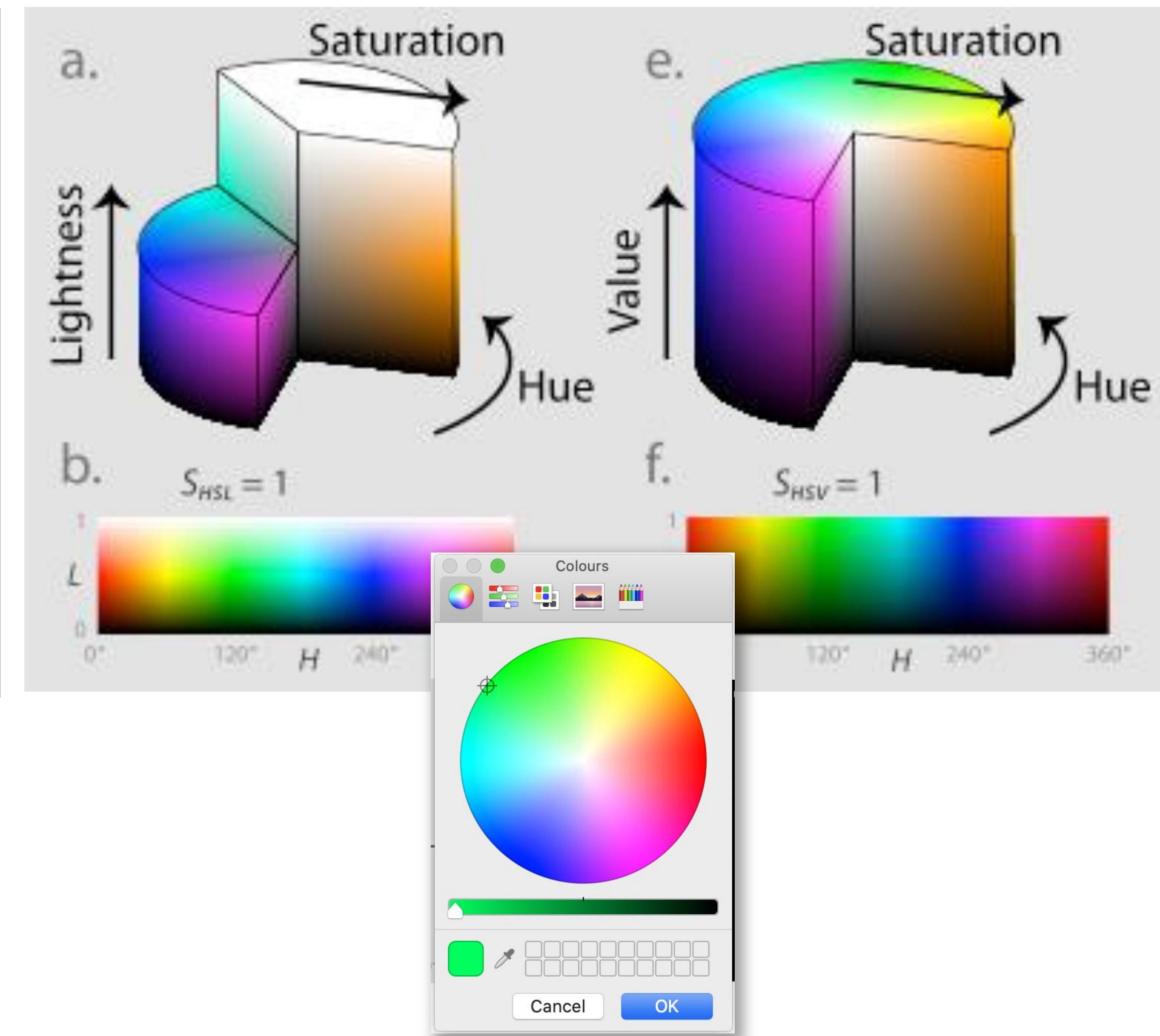


# Color spaces

RGB

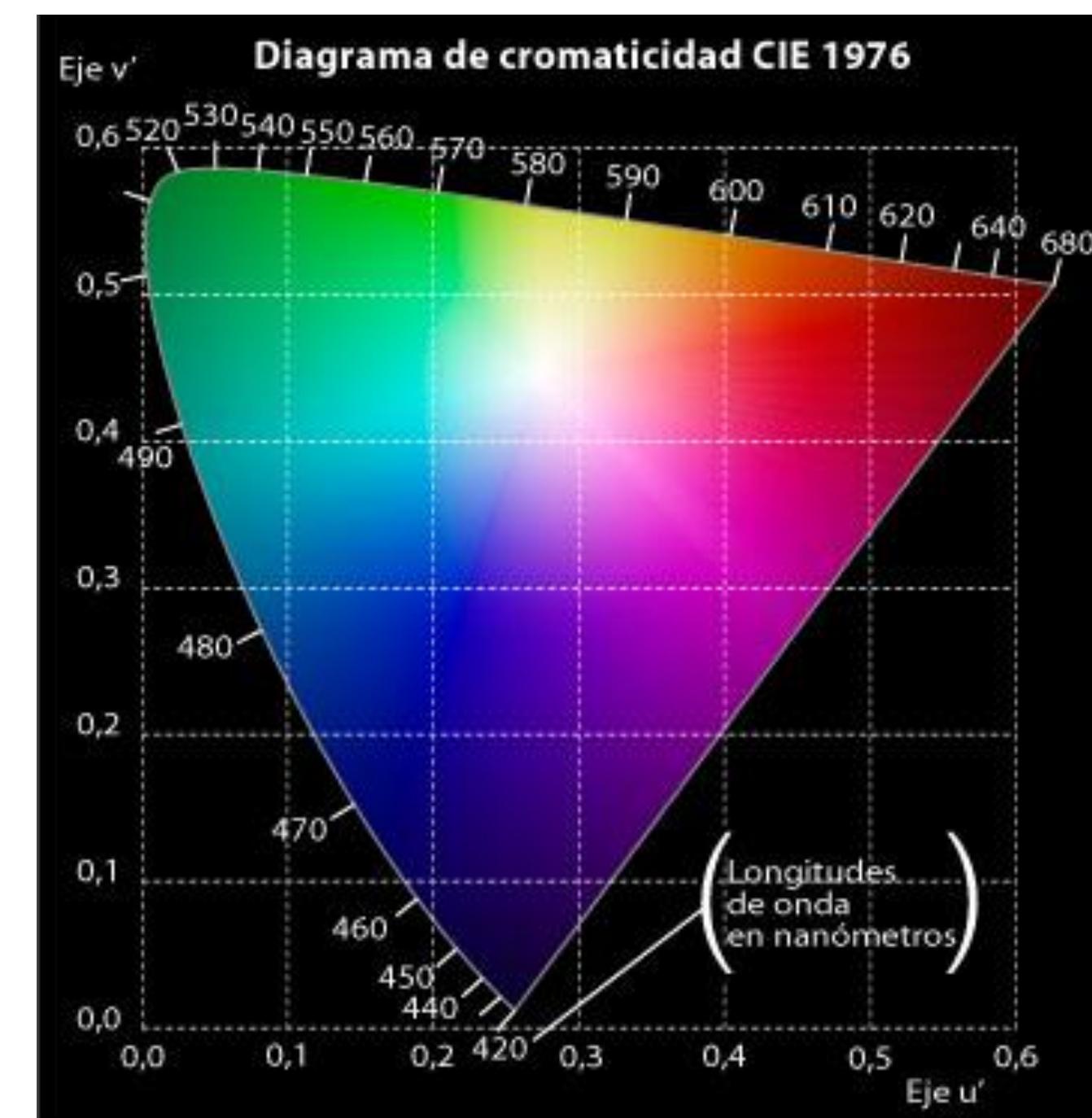


HSL



HSV

CIEL

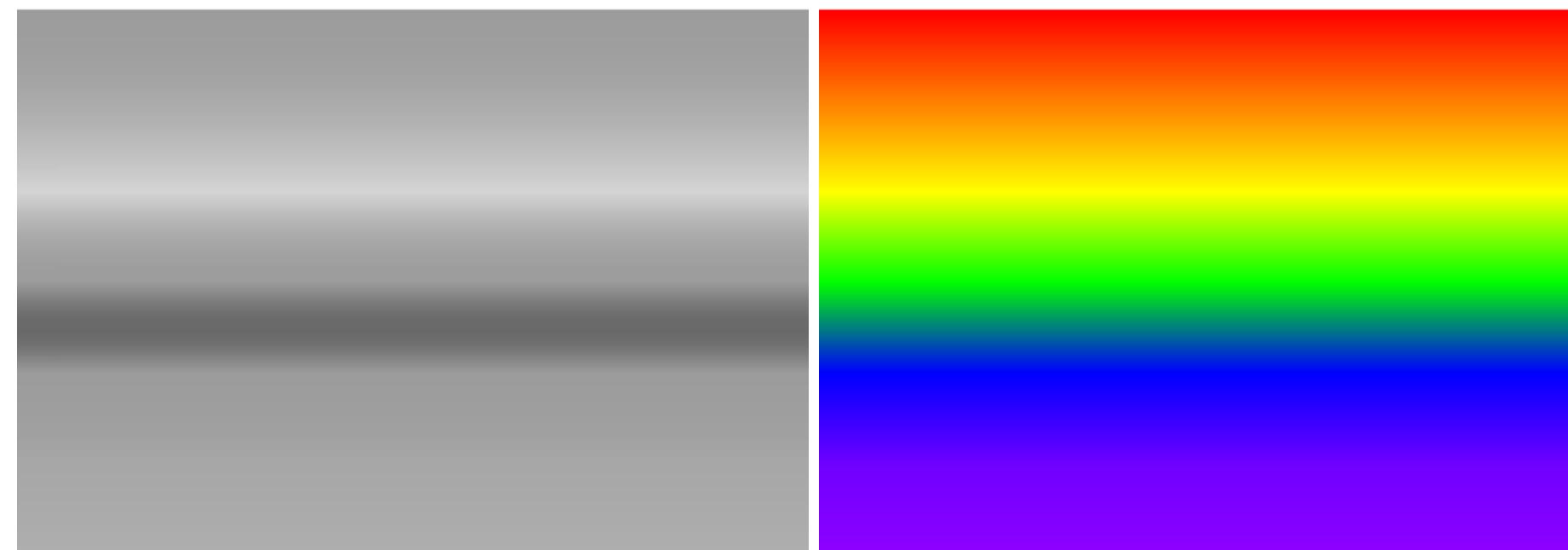


# Escala arcoíris

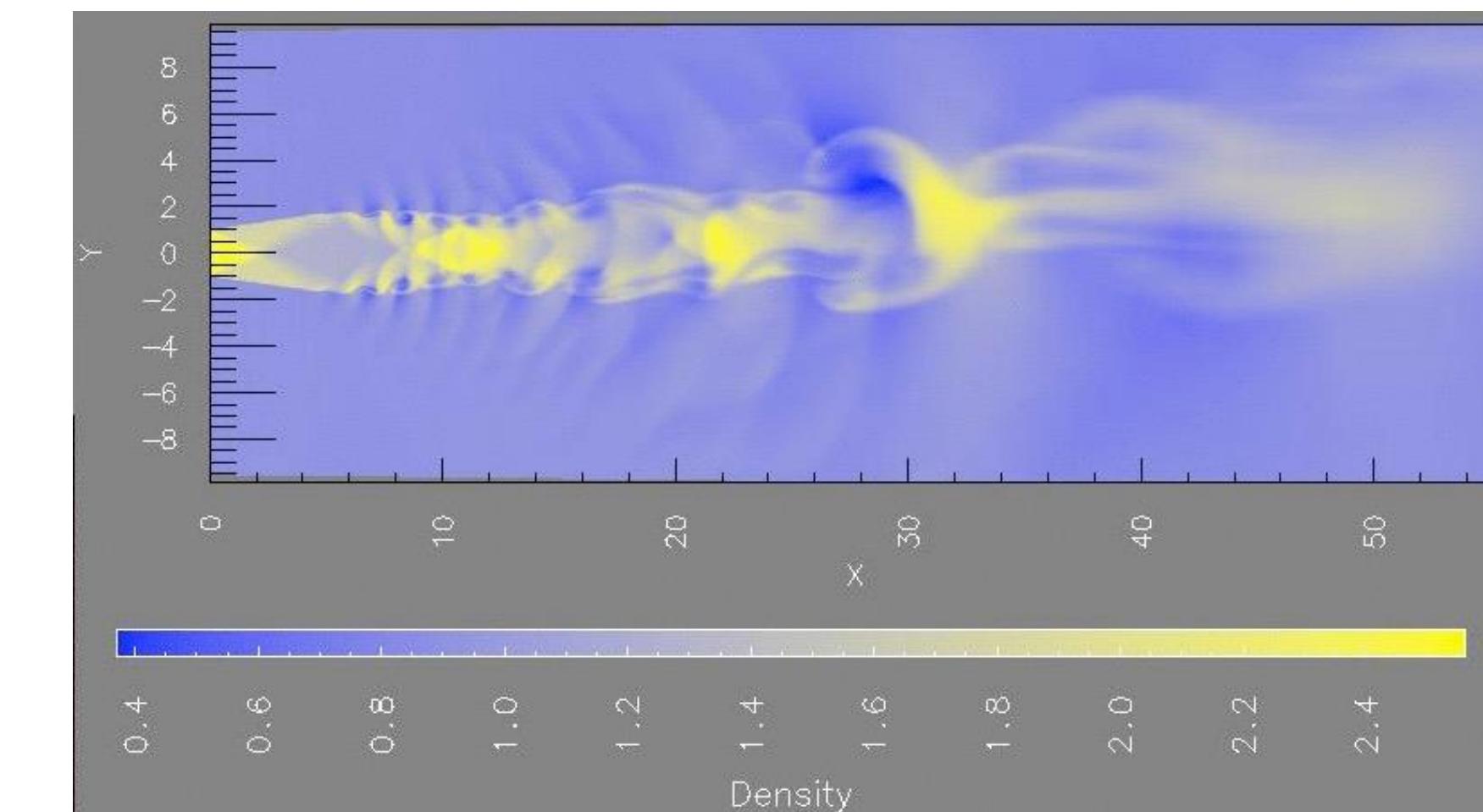
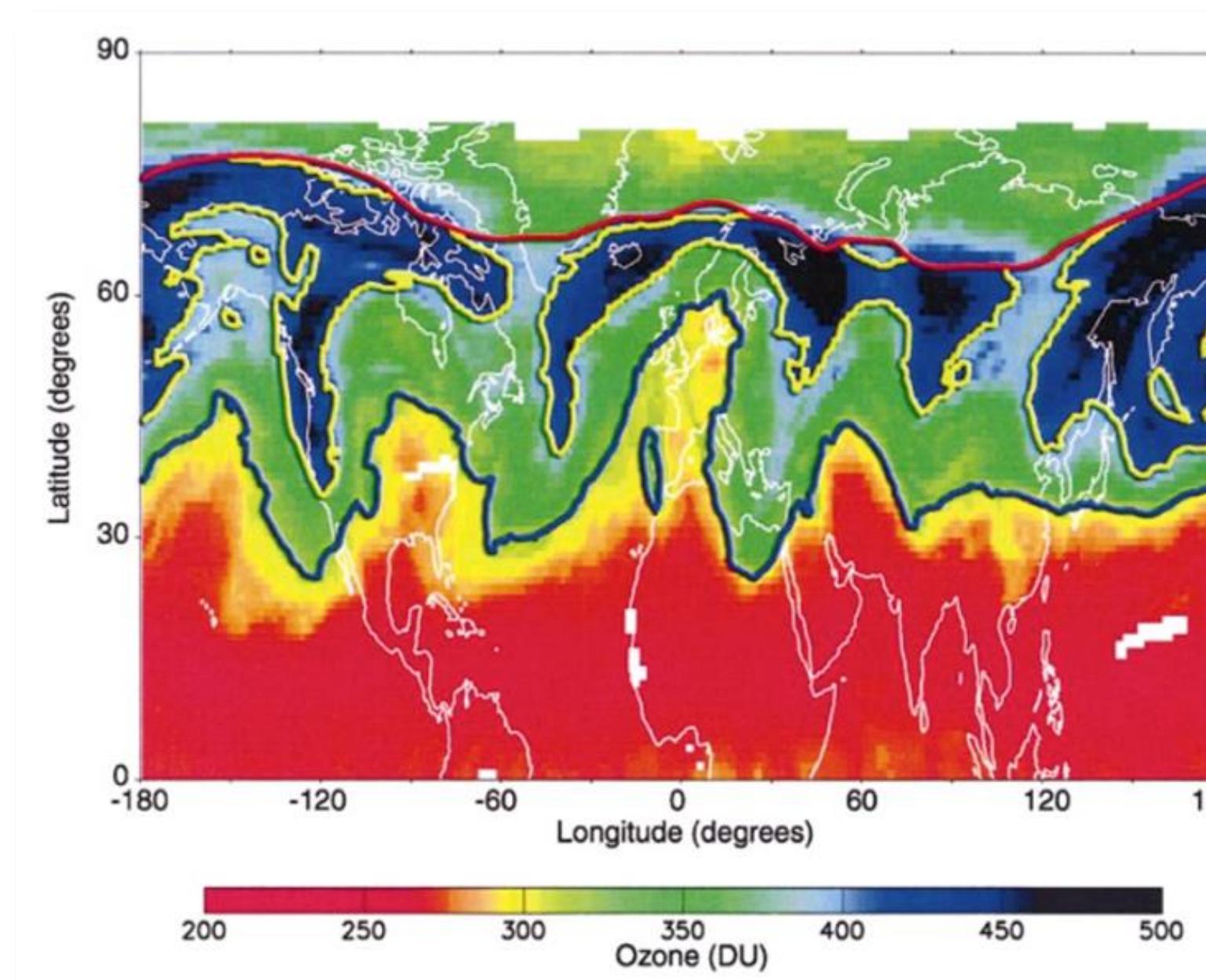
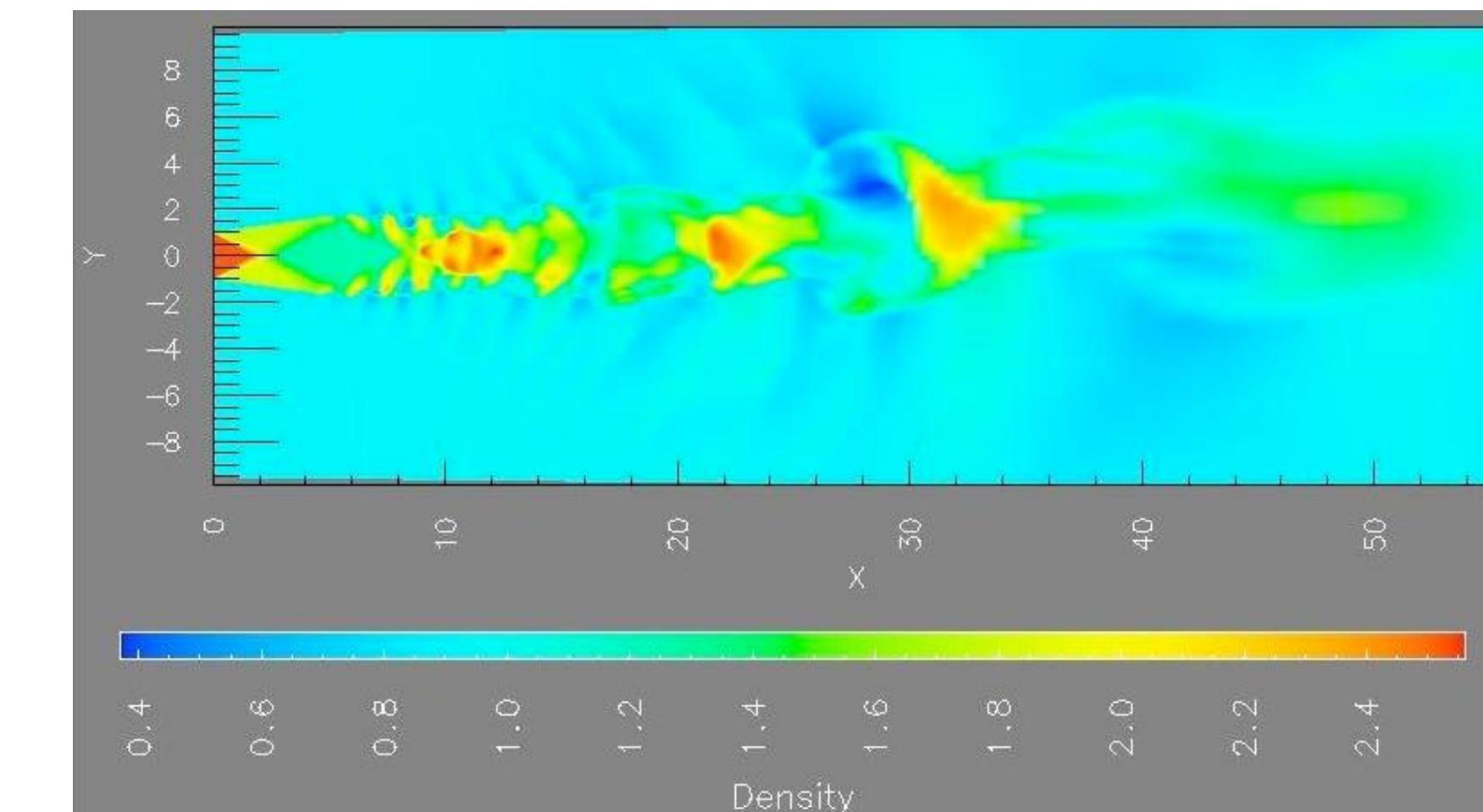
Default en varios softwares de visualización



- Los tonos no tienen un orden inherente



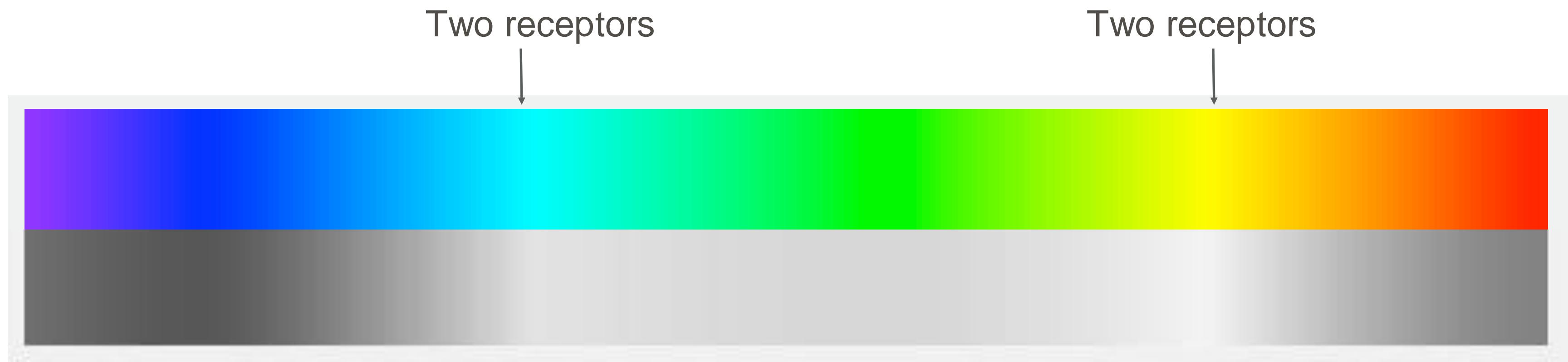
- Es más difícil ver algunos detalles
- Aparecen boundaries que no existen en realidad



[A Rule-based Tool for Assisting Colormap Selection. Bergman,., Rogowitz, and. Treinish. Proc. IEEE Visualization (Vis), pp. 118–125, 1995.]

Problemas de la escala arcoíris, variación no-lineal y la dificultad para distinguir regiones:

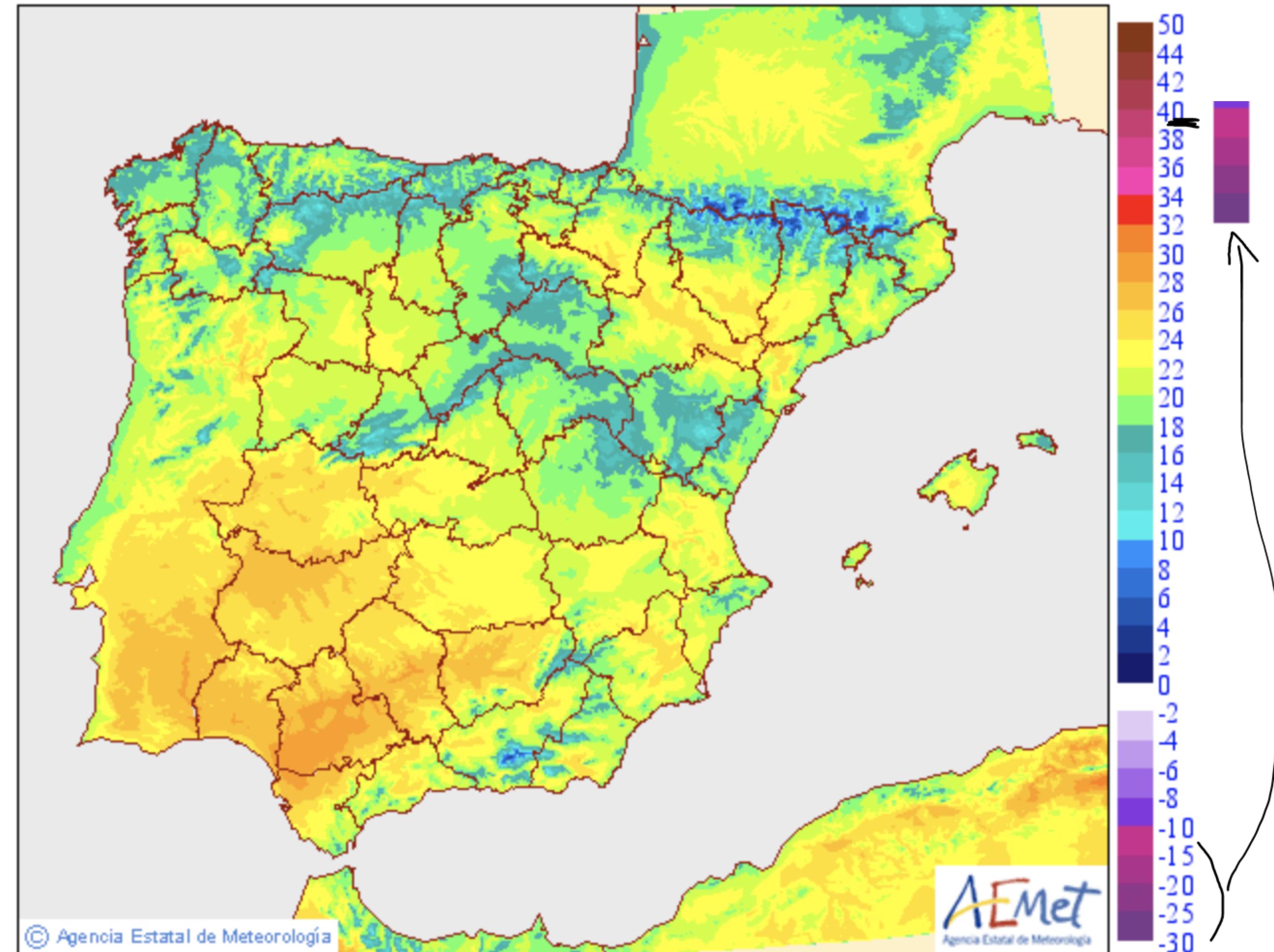
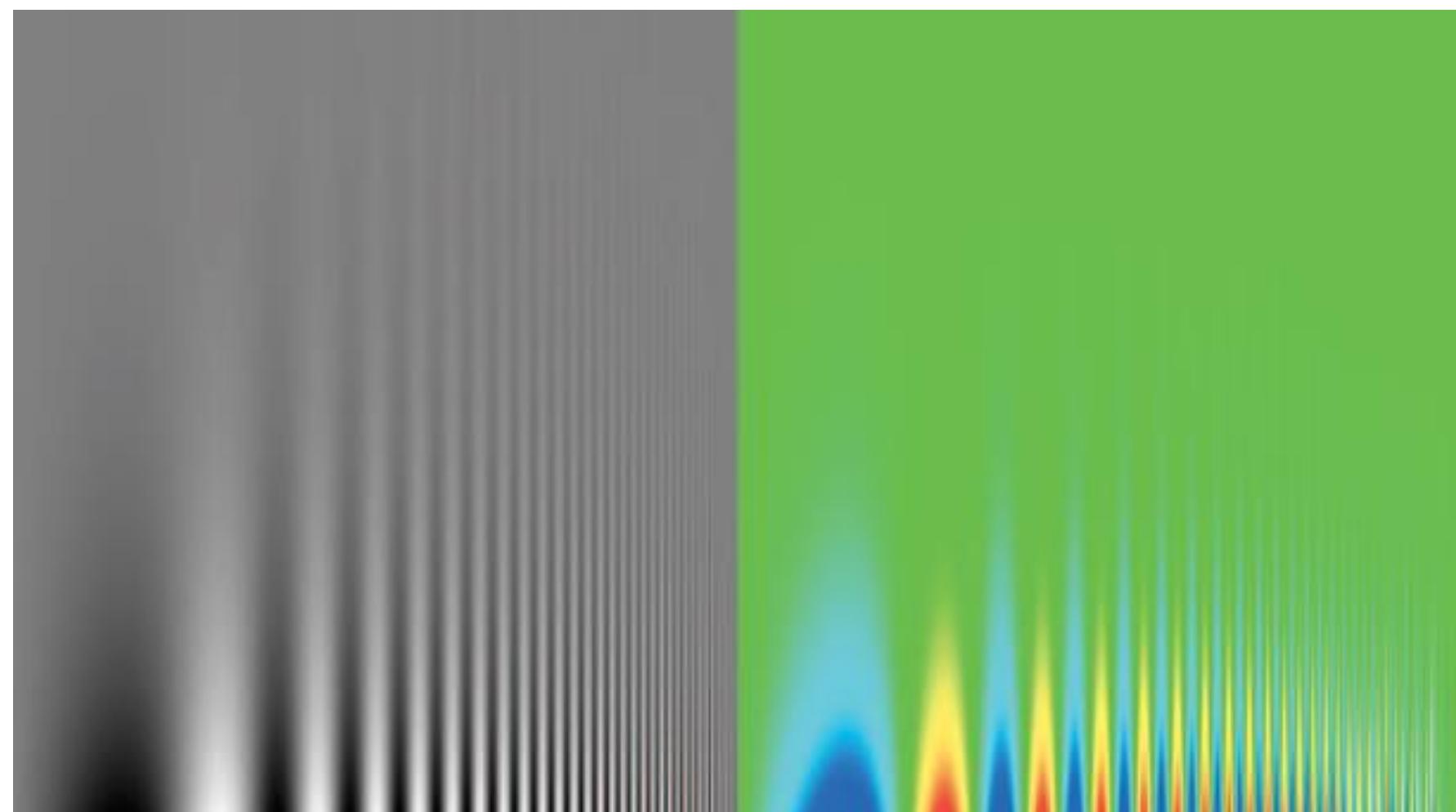
- Sobreexcitación de receptores en algunos puntos, que rompen la linealidad de la escala.



# Escala arcoíris

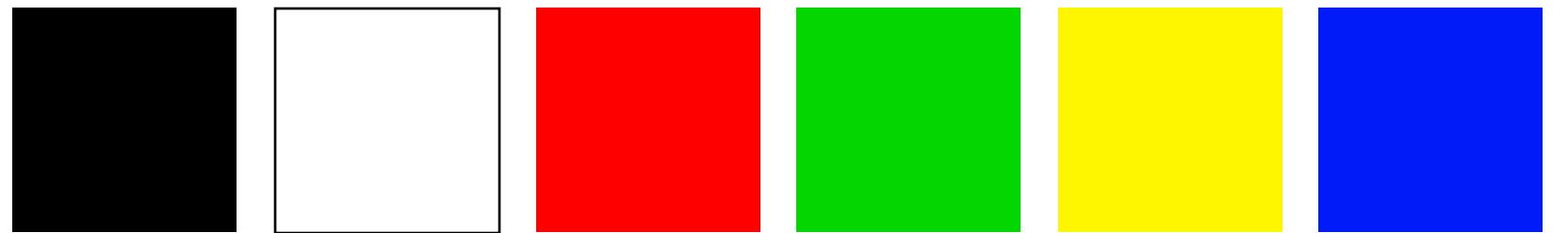
No tiene en cuenta cómo percibimos el color

- No tiene un orden inherente
- Hay colores que percibimos más intensamente que otros
- “Bandas” perceptuales
- Pérdida de detalle



# Channel Properties

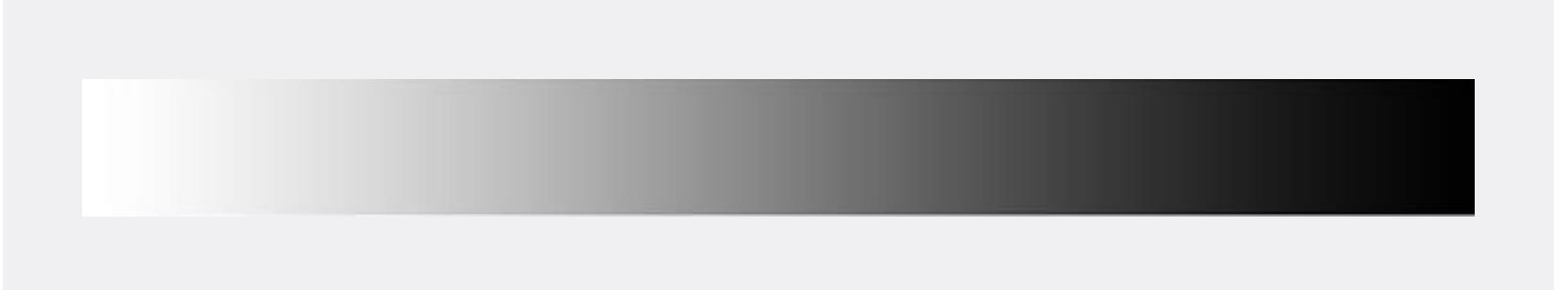
Tono (Hue)



Saturation



Luminance/Lightness/Brightness



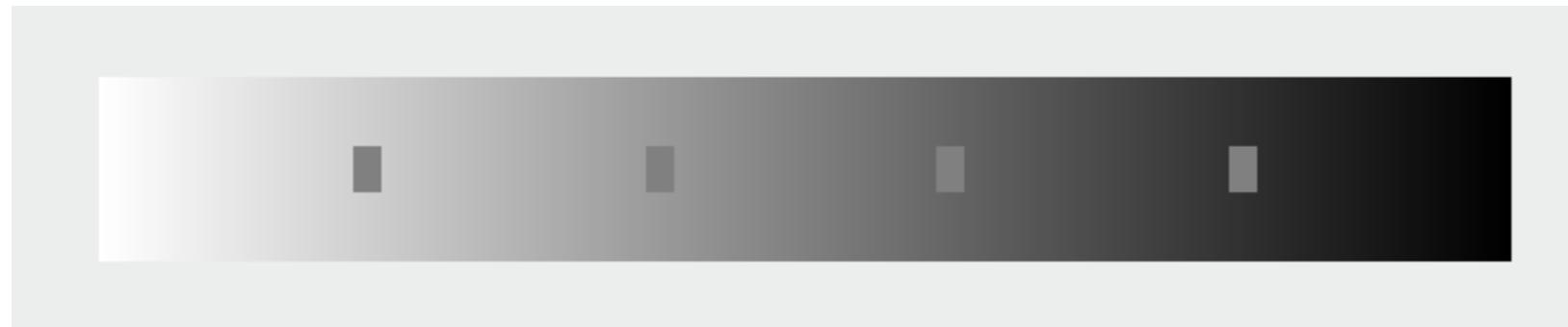
Contrast



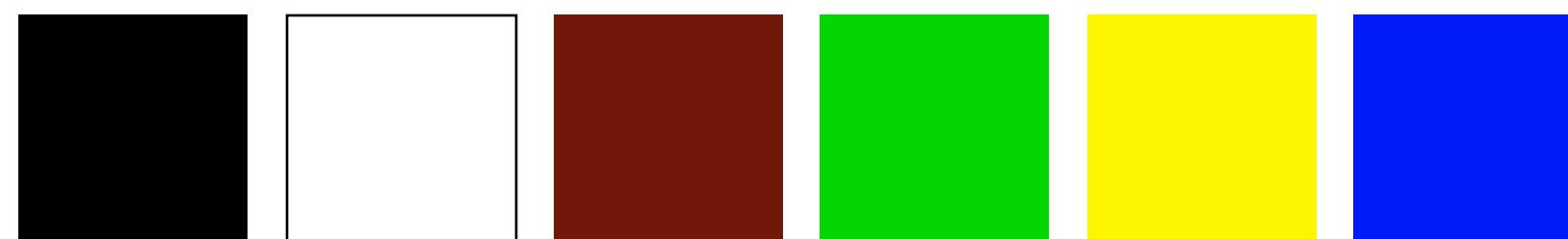


# Channel Properties

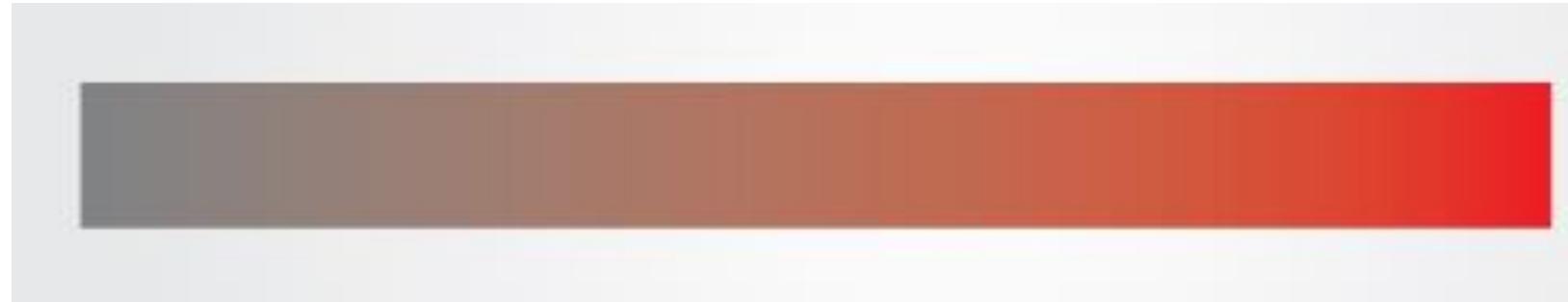
## Contrast



## Unique hues



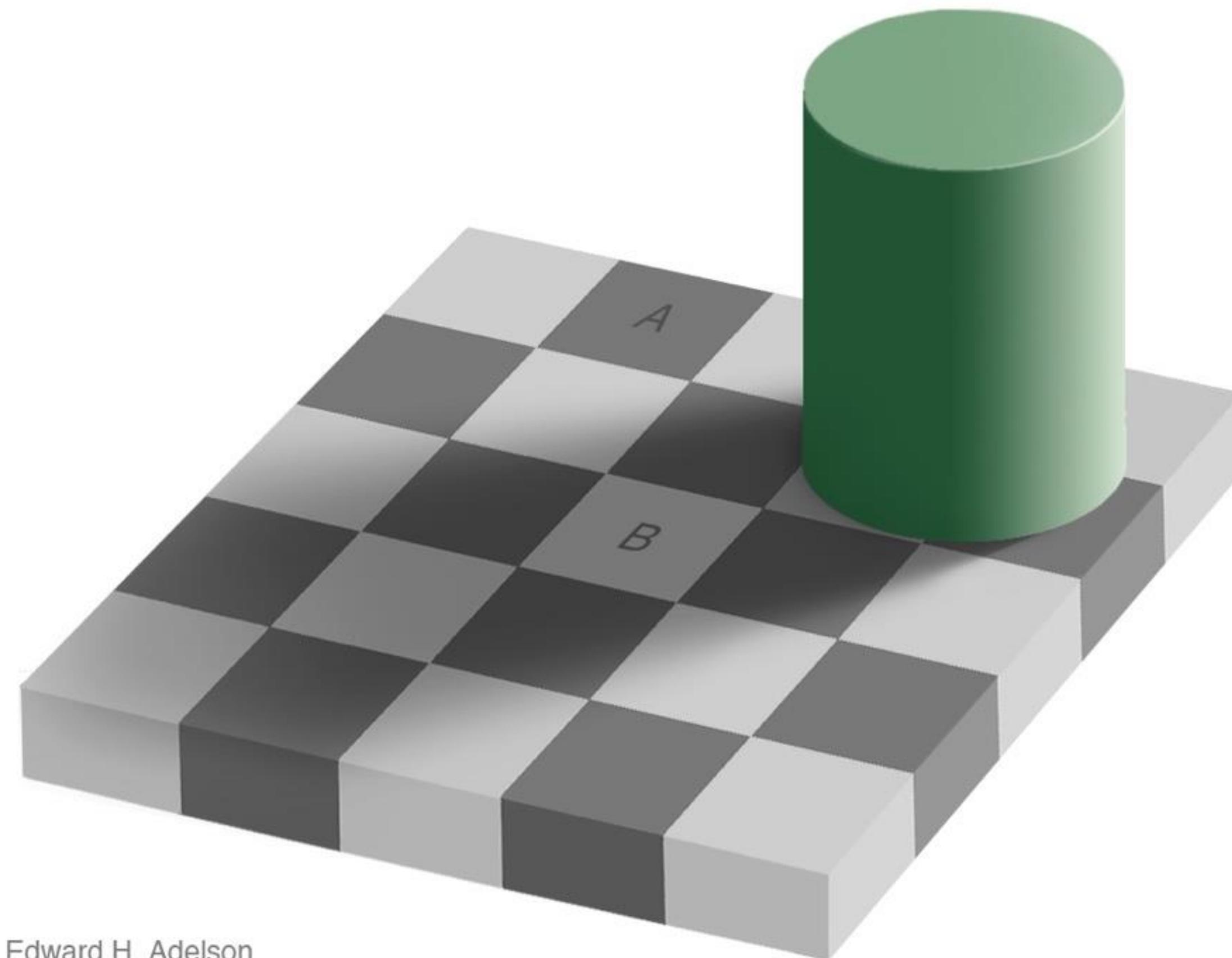
## Saturation



## Lightness



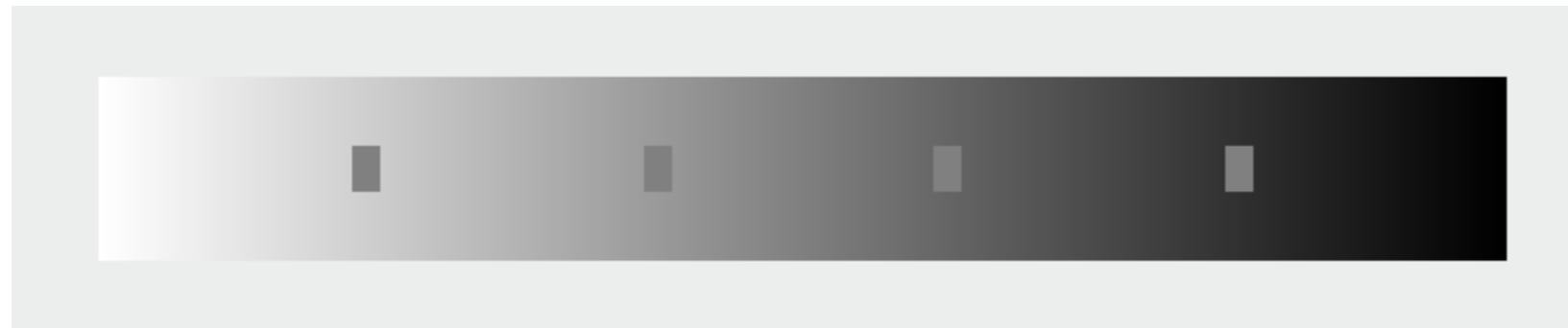
## Simultaneous Contrast



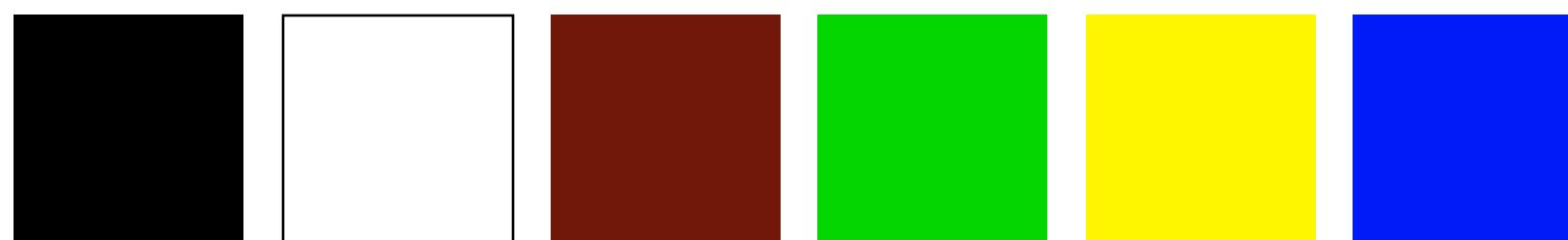
Edward H. Adelson

# Channel Properties

## Contrast



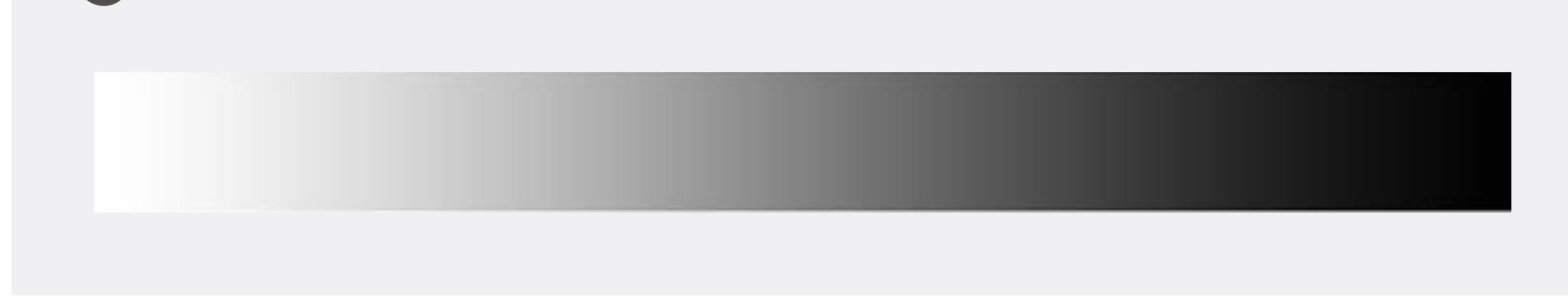
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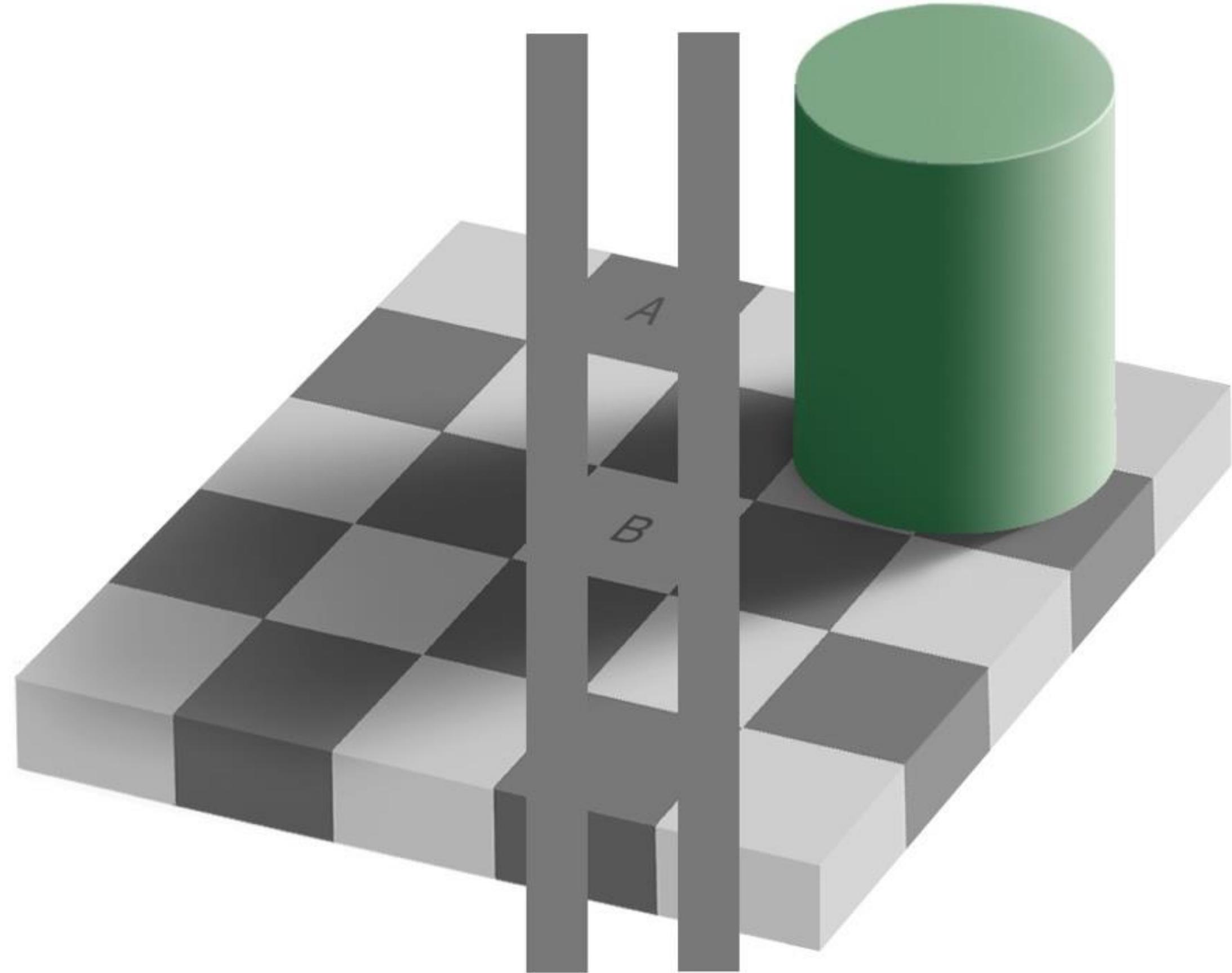
## Saturation



## Lightness

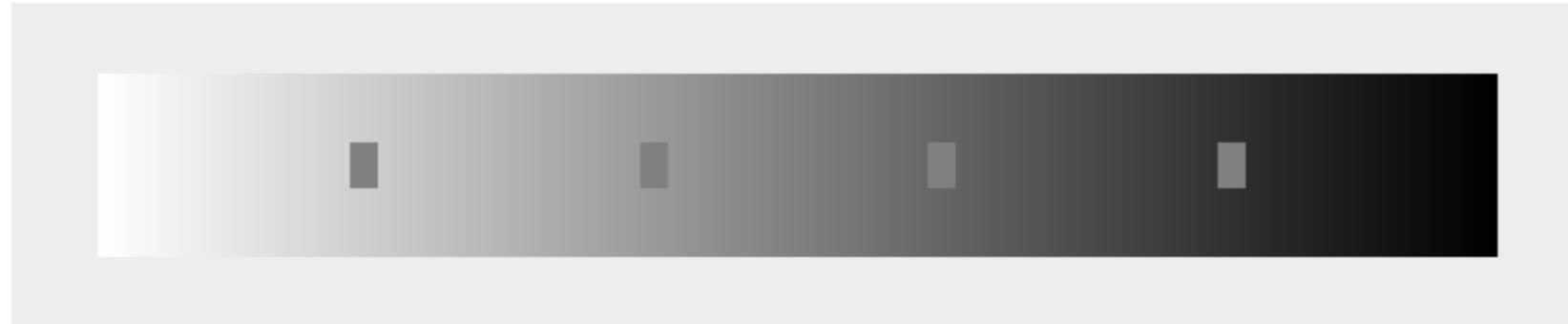


## Simultaneous Contrast

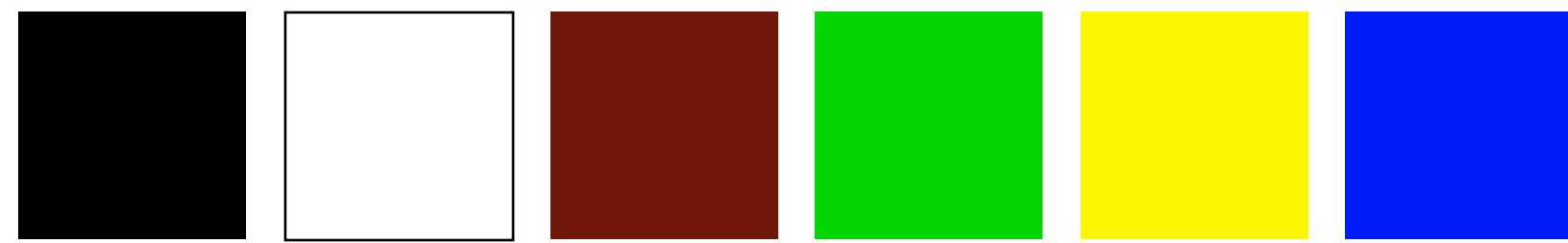


# Channel Properties

## Contrast



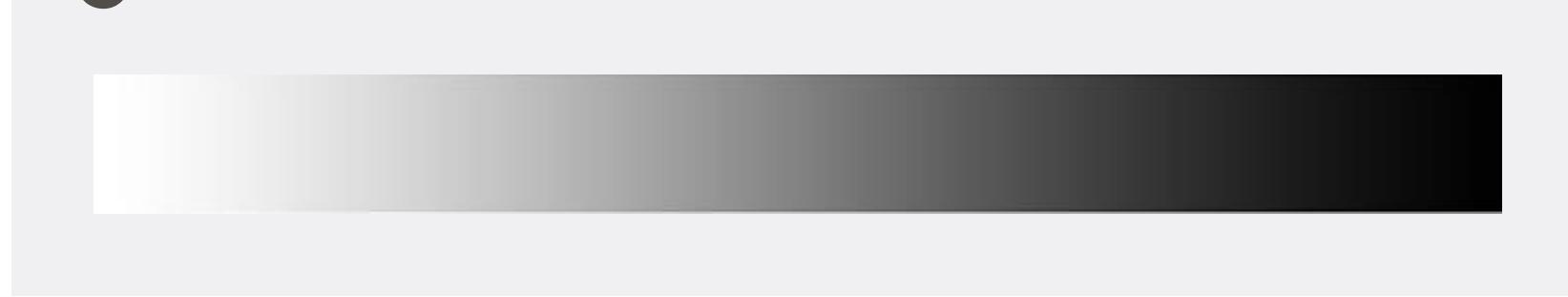
## Unique hues



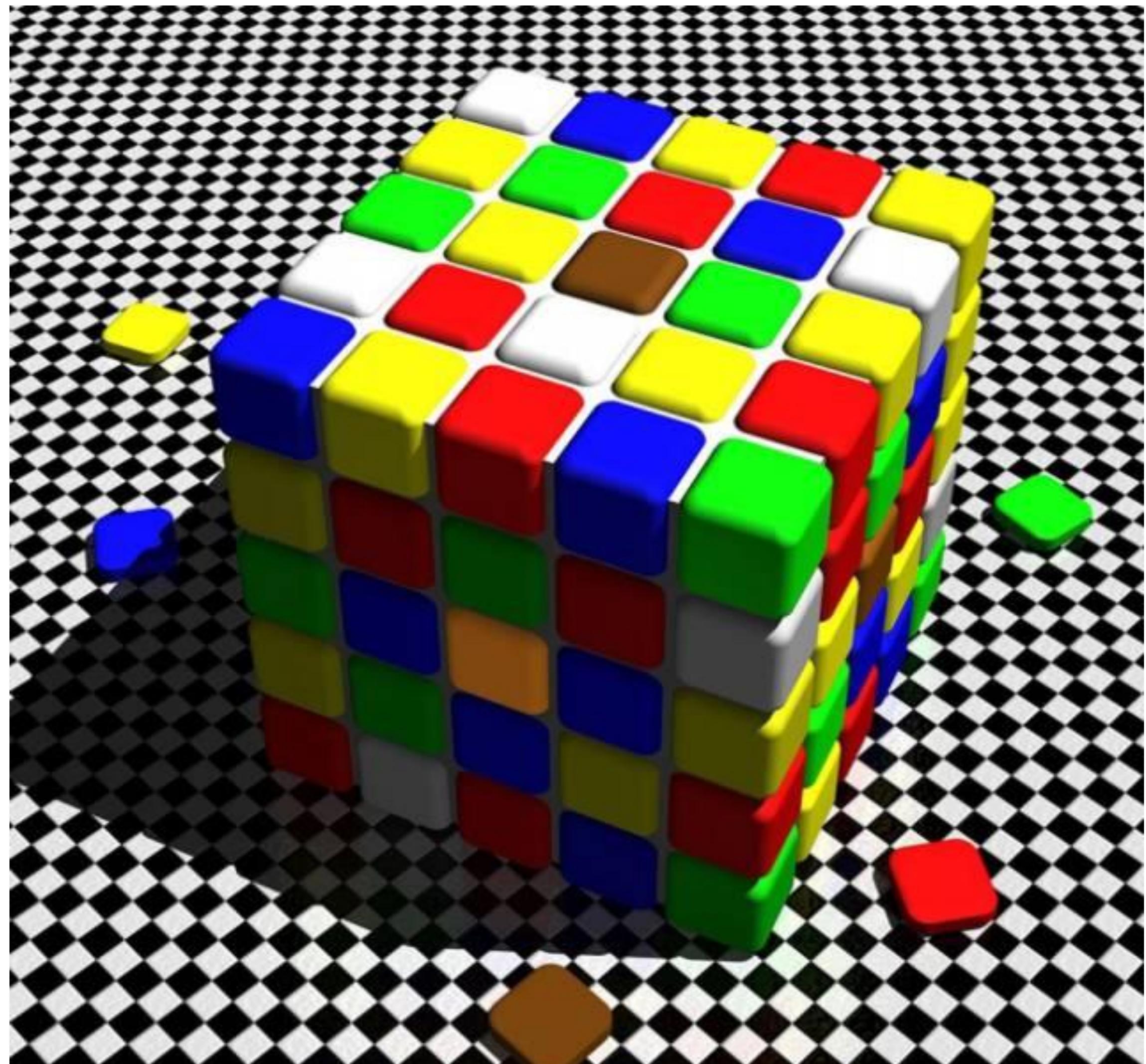
## Saturation



## Lightness



## Color appearance

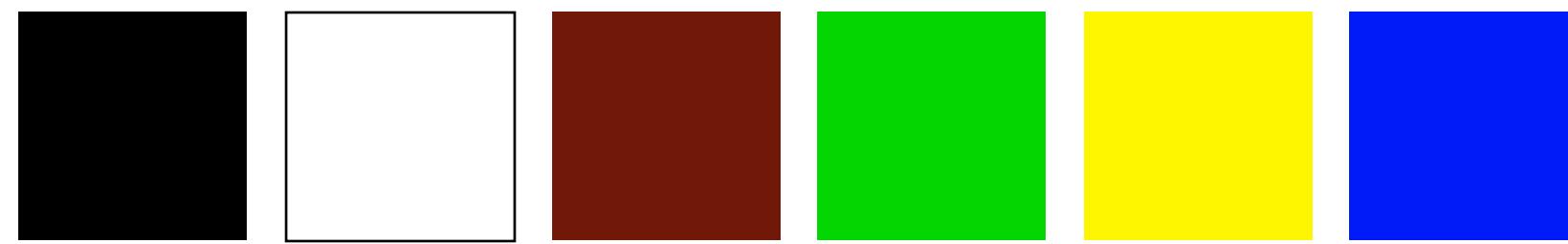


# Channel Properties

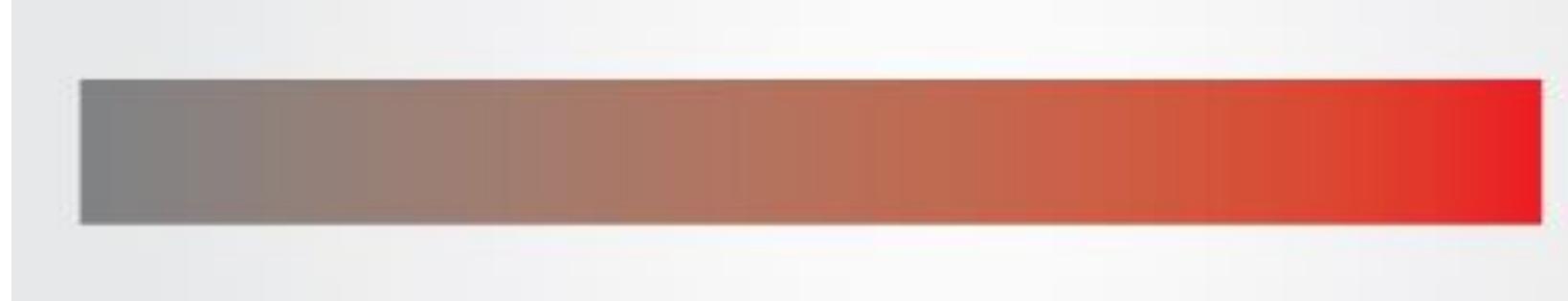
## Contrast



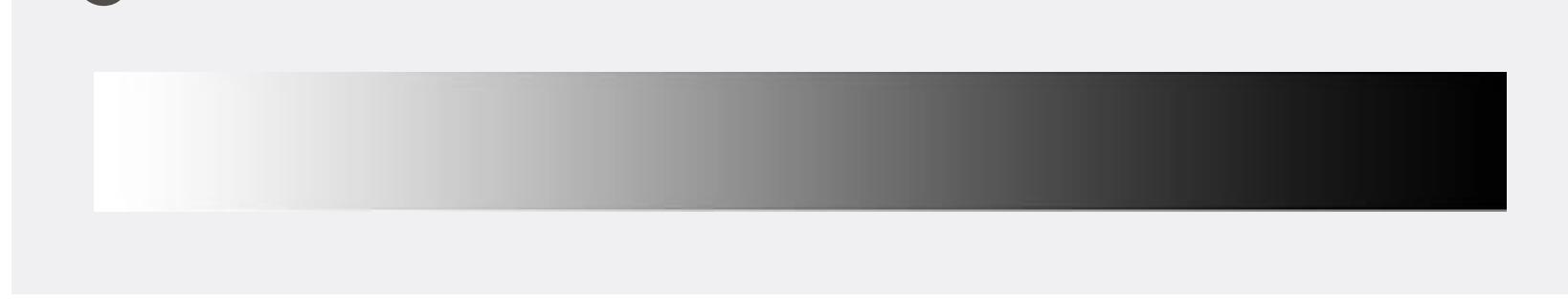
## Unique hues



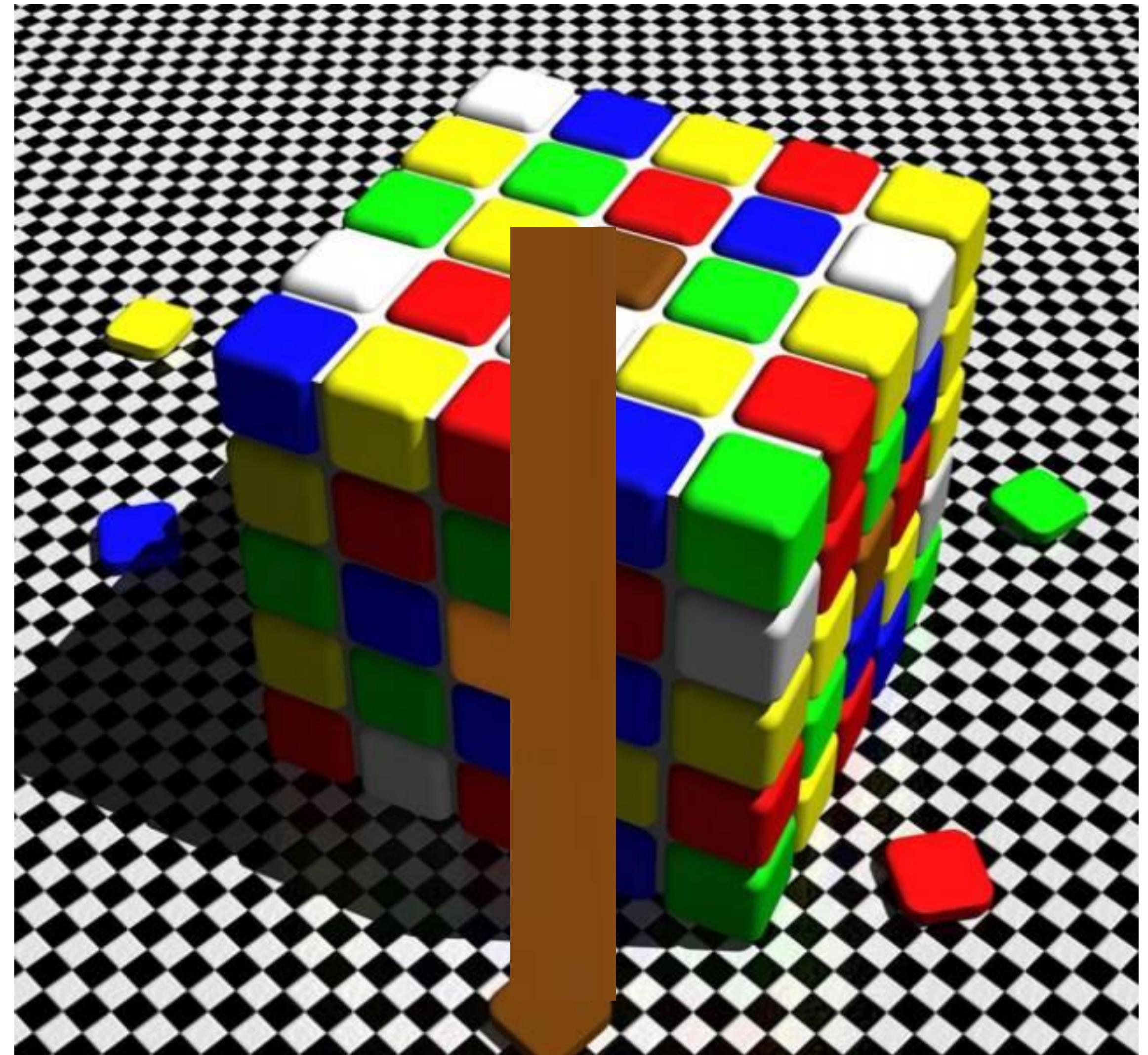
## Saturation



## Lightness



## Color appearance



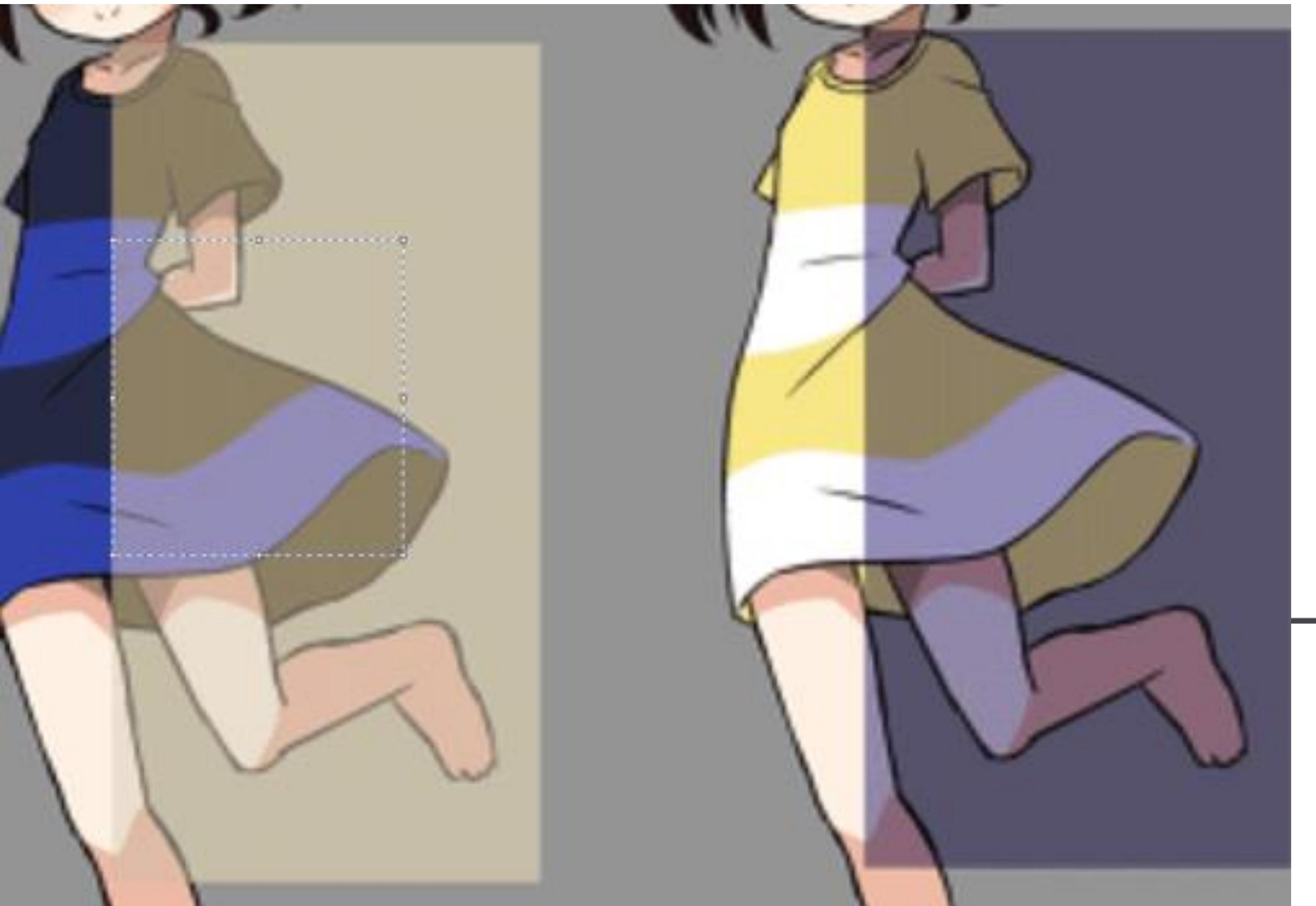
# Relatividad

- Nuestro Sistema perceptual se basa fundamentalmente en juicios relativos, no absolutos
- El contexto que rodea a los elementos modula la aplicación de **Discriminabilidad** y **Precisión**



A

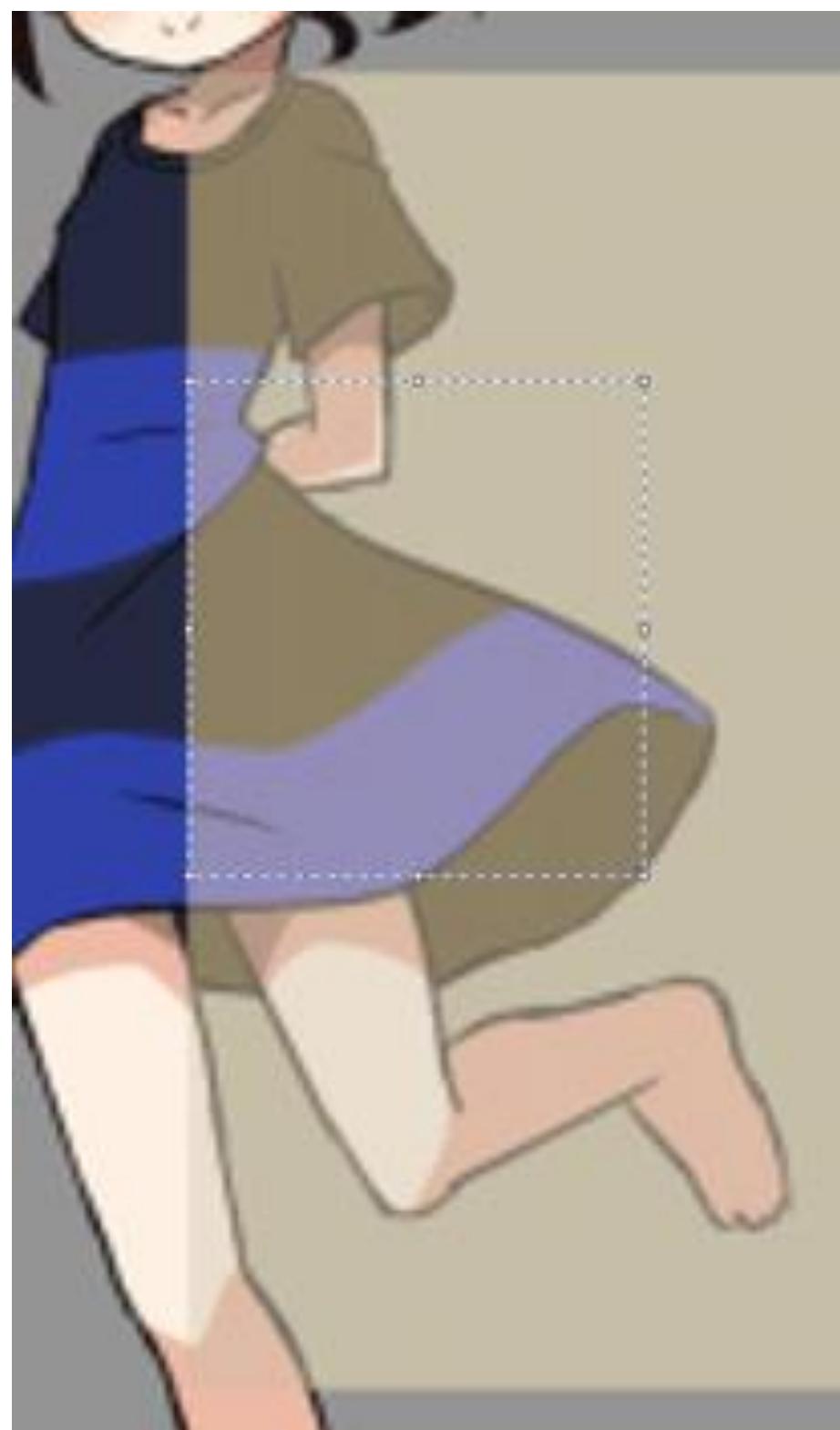
Unfram  
Unalign





R177, G160, B164

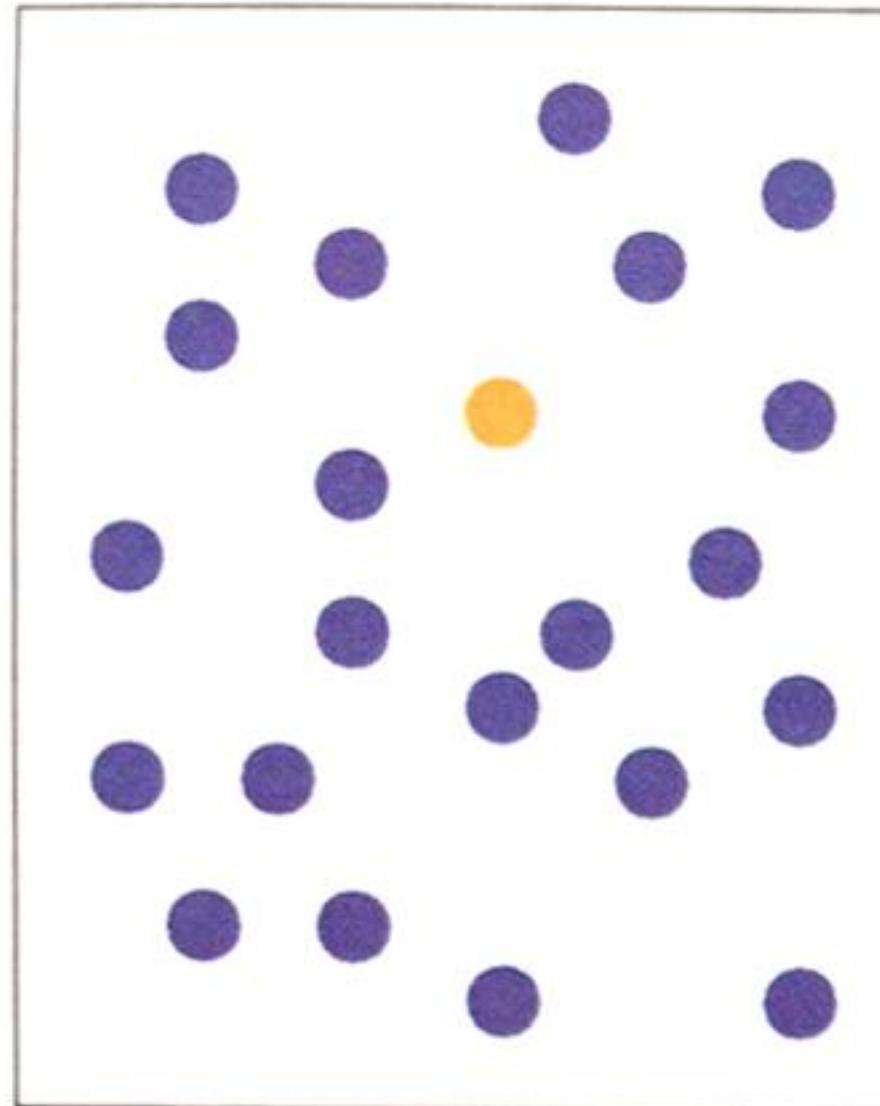
Akiyoshi kitaoka



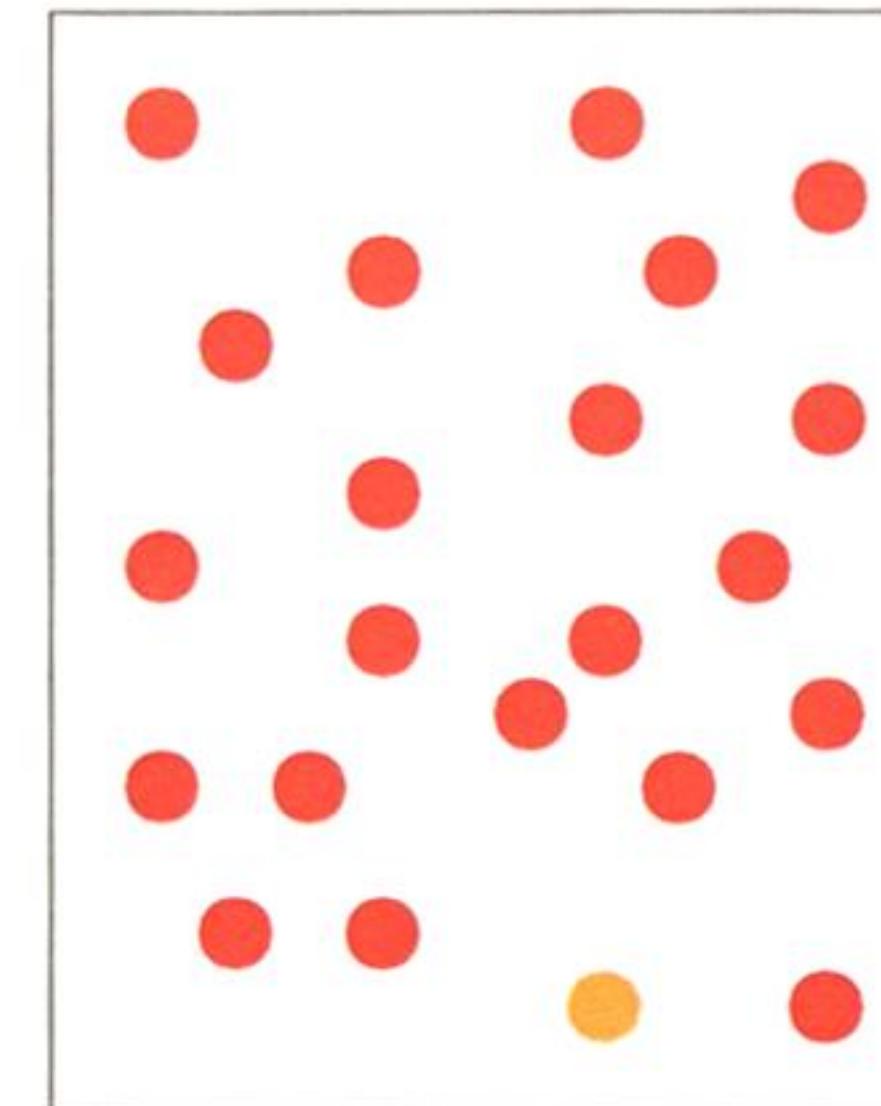


Akiyoshi kitaoka

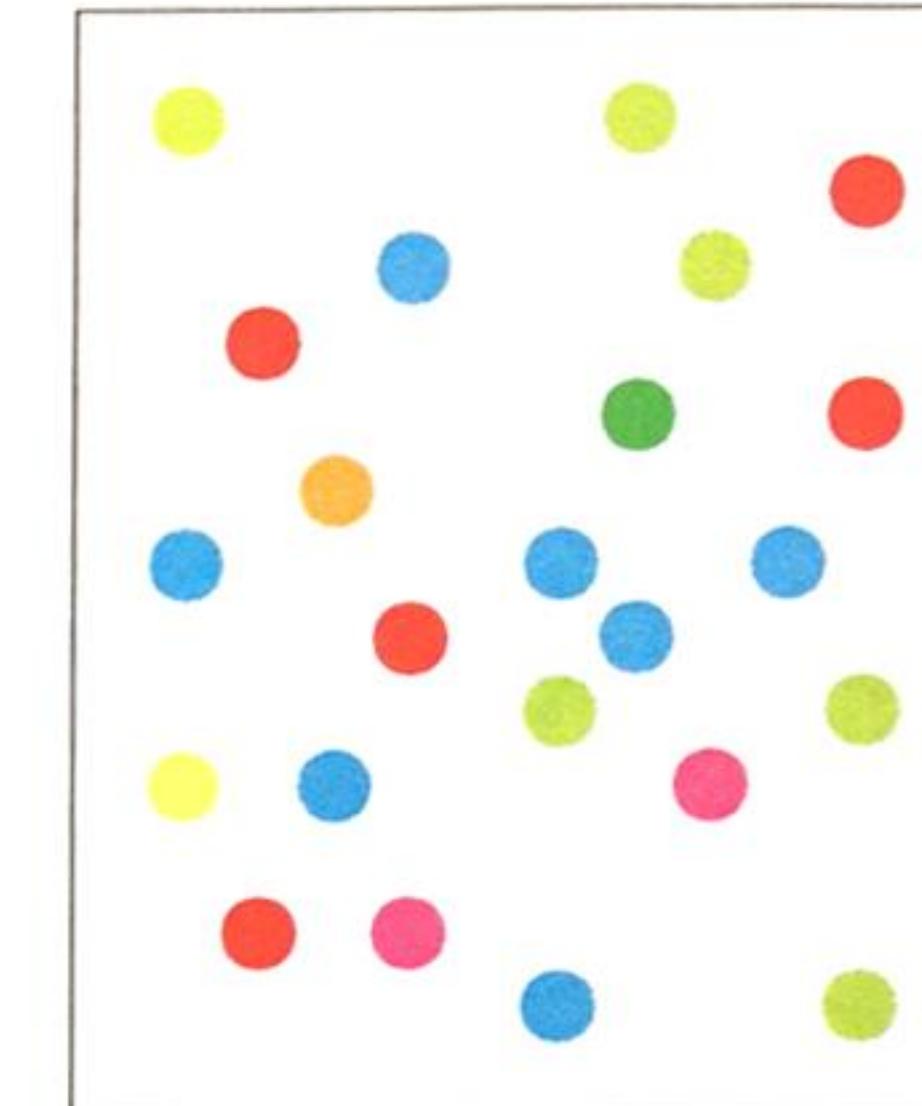
## Percepción del Color - Contraste



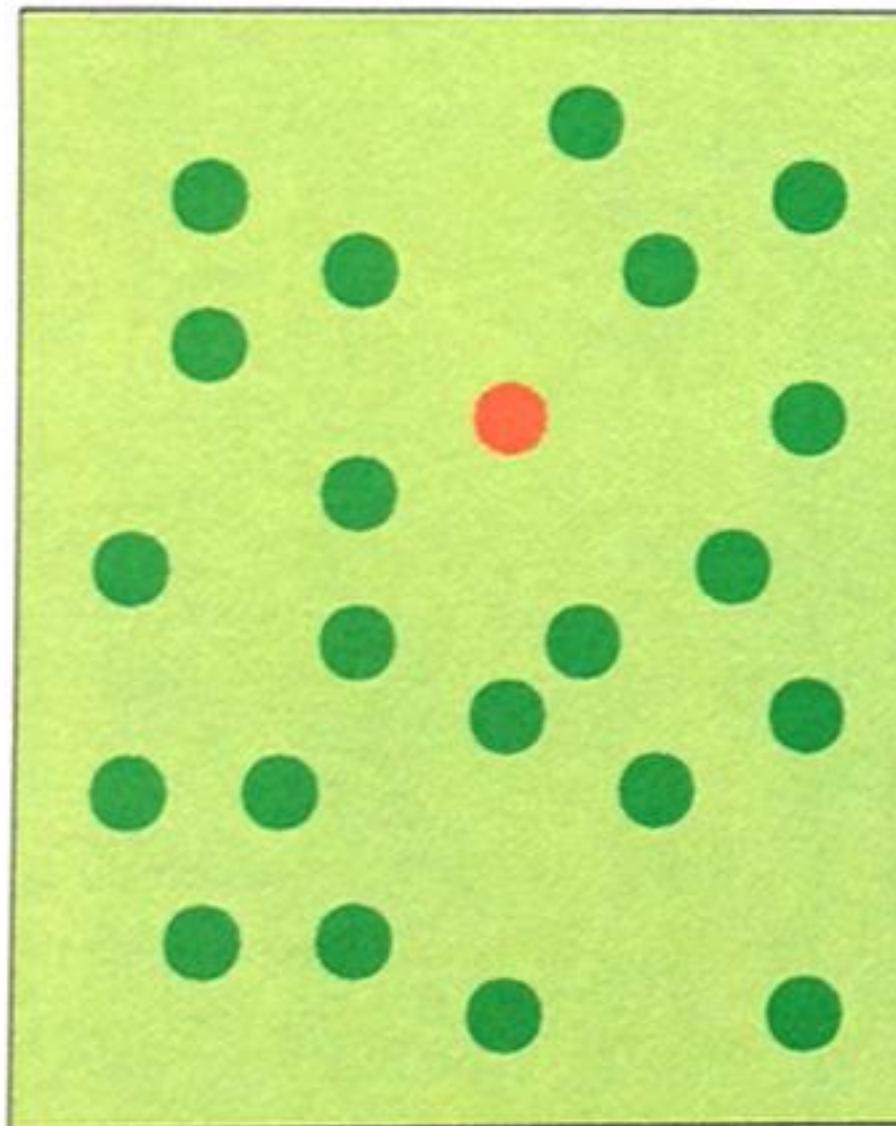
More contrast=easier



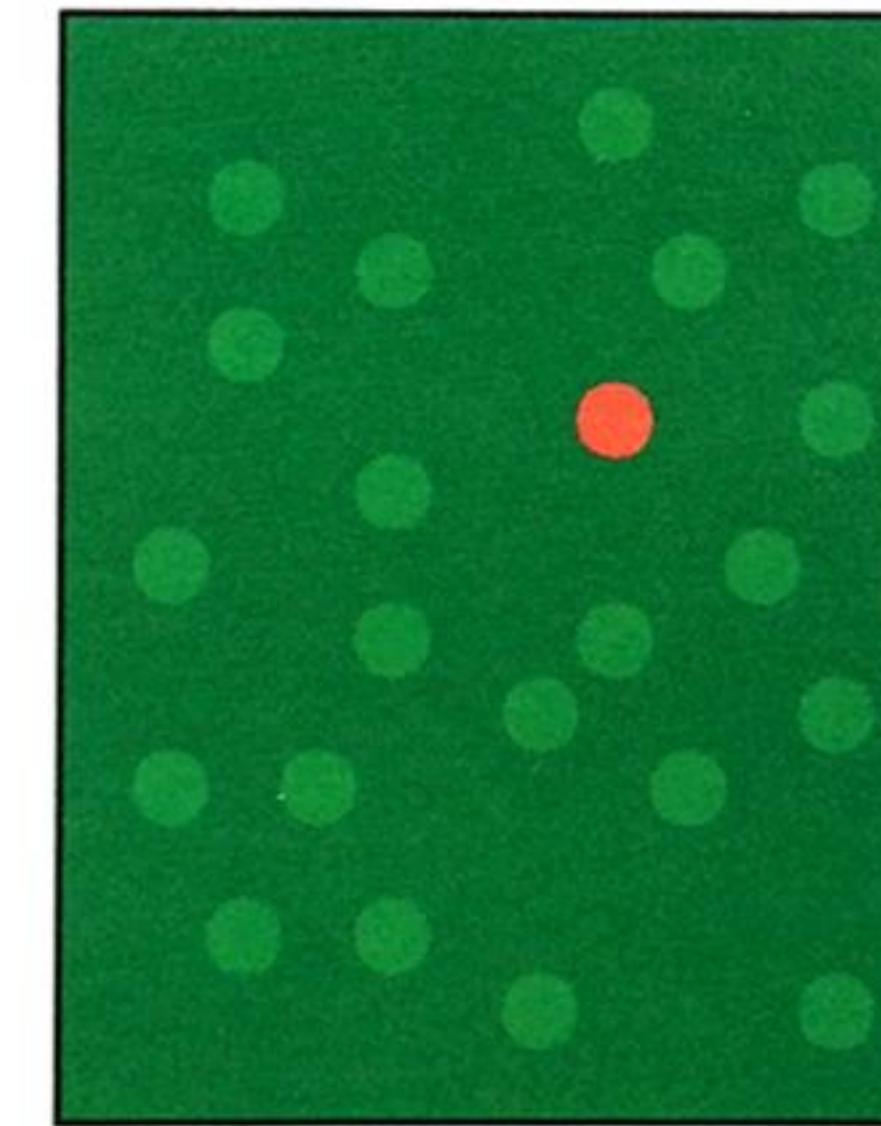
Less contrast=difficult



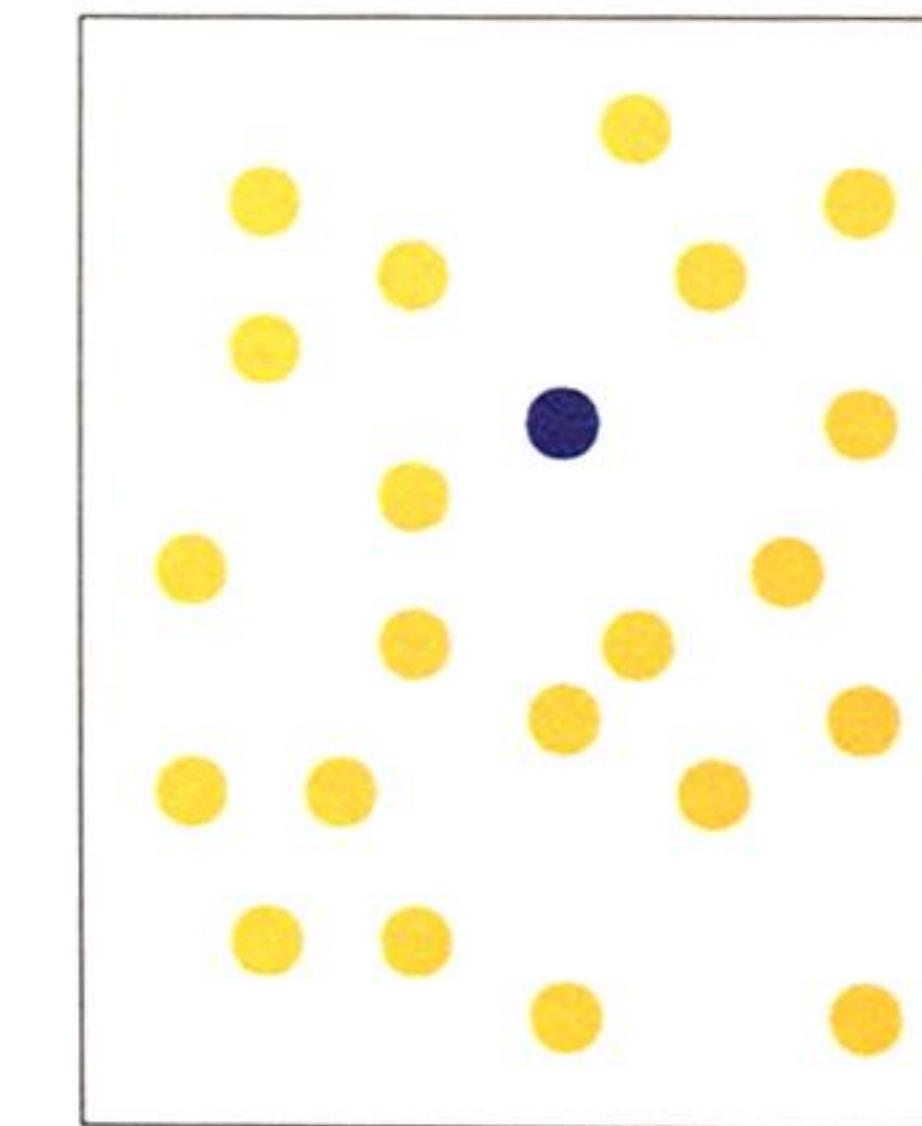
More difficult



Similarity=Easy to exclude



L+H = Easiest search



Opposite = Easy too

- El contraste facilita la detección
- Hue homogéneo
- Variación en Hue y Lightness= Más fácil

# R cheatsheet

Todo esto nos sirve para saber que:

- Hay varios modelos de color, no todos son perceptualmente correctos.
- Para escalas de color necesitamos modelos de interpolación no lineal.
- Algunos colores tienen mayor contraste entre si. Podemos usarlo para dirigir la atención.
- El tamaño modula la percepción de los colores
- Evitar artefactos (contraste simultaneo, apariencia de color)

## R color cheatsheet

Finding a good color scheme for presenting data can be challenging. This color cheatsheet will help!

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Two additional characters (with the same scale) can be added to the end to describe transparency (#rrggbbaa)

### R has 657 built in color names

Example:  
To see a list of names:  
[colors\(\)](#)

peachpuff4

These colors are displayed on P. 3.

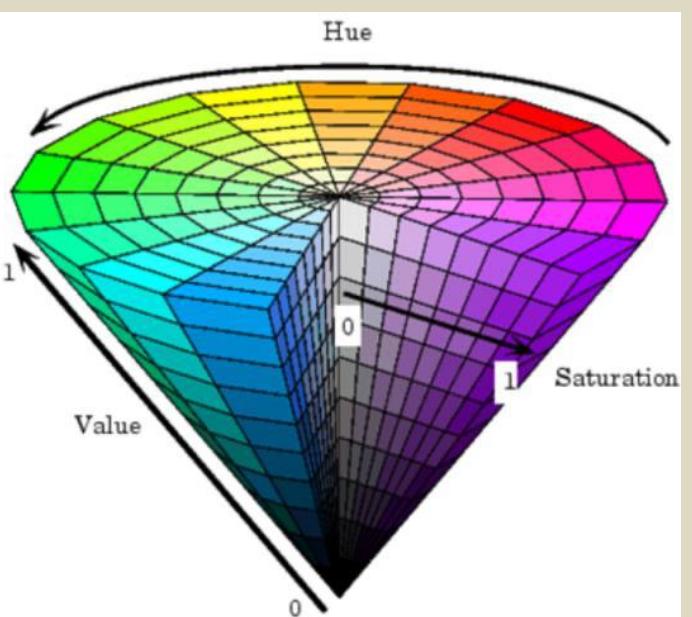
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[rgb\(r, g, b, maxColorValue=255, alpha=255\)](#)
- HSV (hue, saturation, value): values range from 0-1, with optional alpha argument  
[hsv\(h, s, v, alpha\)](#)
- HCL (hue, chroma, luminance): hue describes the color and ranges from 0-360; 0 = red, 120 = green, blue = 240, etc. Range of chroma and luminance depend on hue and each other  
[hcl\(h, c, l, alpha\)](#)

#### A few notes on HSV/HLC

HSV is a better model for how humans perceive color. HCL can be thought of as a perceptually based version of the HSV model....blah blah blah...

Without delving into color theory: color schemes based on HSV/HLC models generally just look good.



R can translate colors to **rgb** (this is handy for matching colors in other programs)  
[col2rgb\(c\("#FF0000", "blue"\)\)](#)

### R Color Palettes

This is for all of you who don't know anything about color theory, and don't care but want some nice colors on your map or figure....NOW!

**TIP:** When it comes to selecting a color palette, **DO NOT** try to handpick individual colors! You will waste a lot of time and the result will probably not be all that great. R has some good packages for color palettes. Here are some of the options

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[heat.colors\(4, alpha=1\)](#)  
> #FF0000FF" "#FF8000FF" "#FFFF00FF" "#FFF80FF"

For the **rainbow** palette you can also select start/end color (red = 0, yellow = 1/6, green = 2/6, cyan = 3/6, blue = 4/6 and magenta = 5/6) and saturation (s) and value (v):  
[rainbow\(n, s = 1, v = 1, start = 0, end = max\(1, n - 1\)/n, alpha = 1\)](#)

[grDevices palettes](#)  
[cm.colors](#)  
[topo.colors](#)  
[terrain.colors](#)  
[heat.colors](#)  
[rainbow](#)  
see P. 4 for options

#### Package: RcolorBrewer

This function has an argument for the number of colors and the color palette (see P. 4 for options).  
[brewer.pal\(4, "Set3"\)](#)

> "#8DD3C7" "#FFFFB3" "#BEBADA" "#FB8072"

To view colorbrewer palettes in R: [display.brewer.all\(5\)](#)  
There is also a very nice interactive viewer:  
<http://colorbrewer2.org/>

### ## My Recommendation ##

#### Package: colorspace

These color palettes are based on HCL and HSV color models. The results can be very aesthetically pleasing. There are some default palettes:

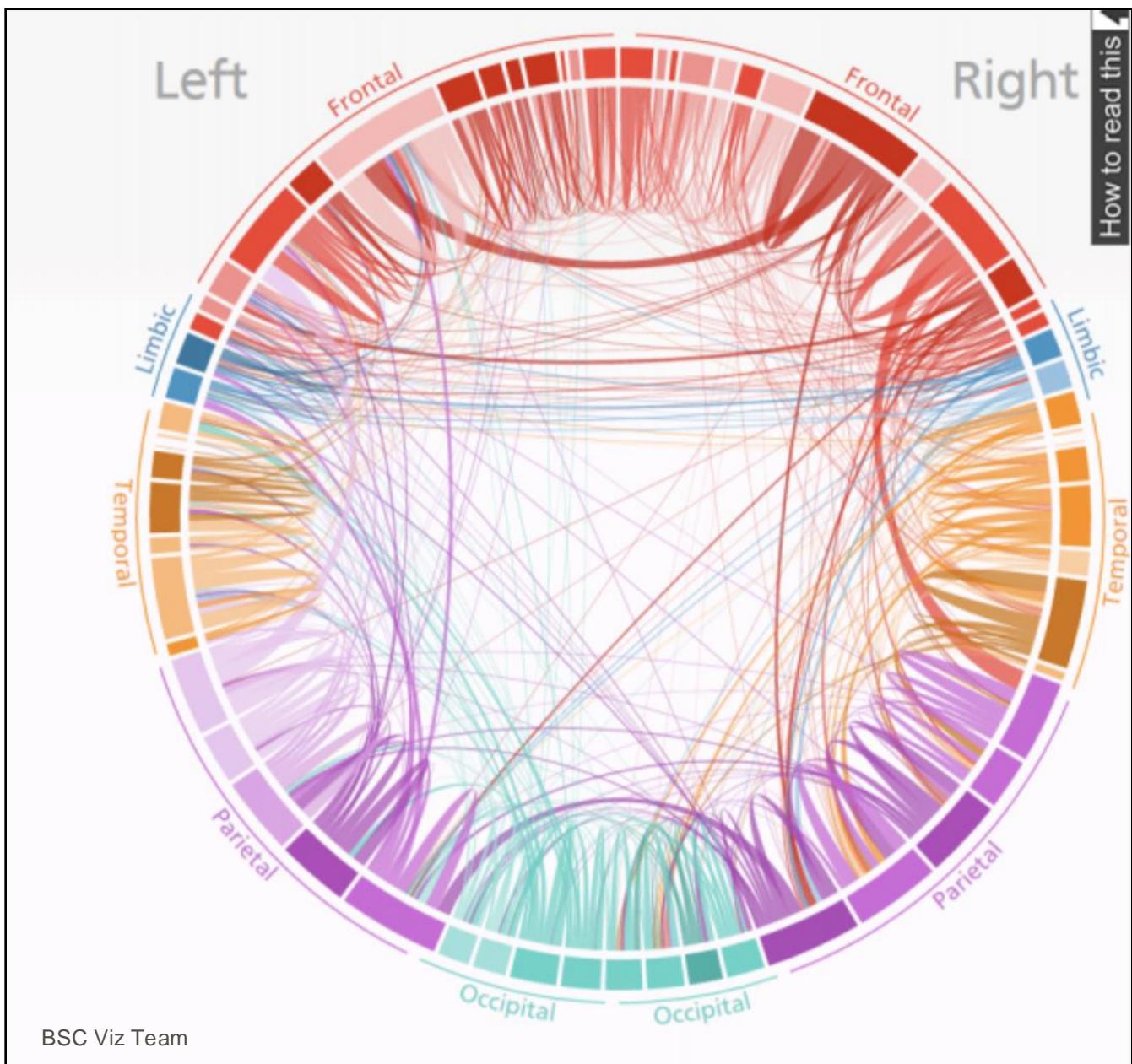
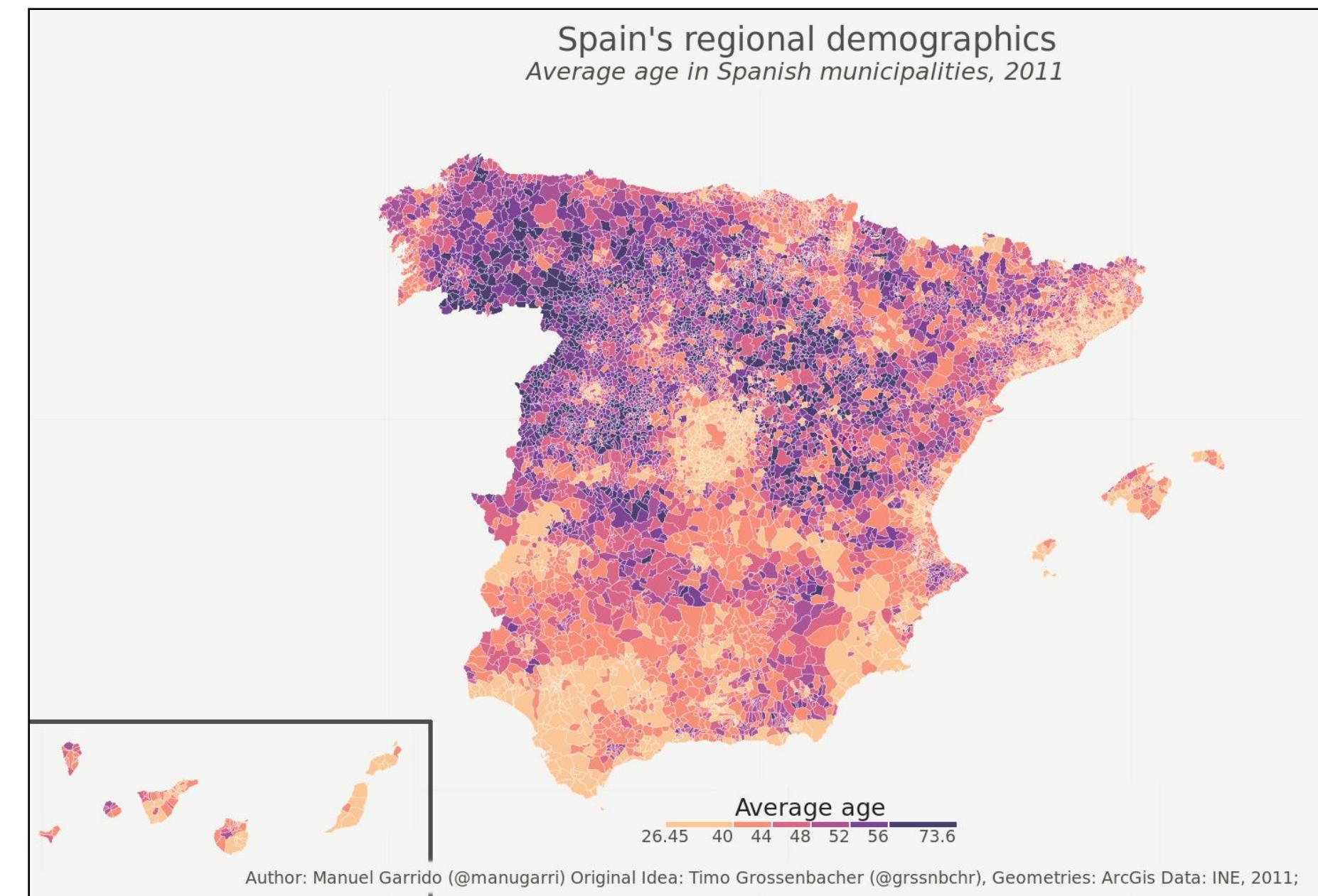
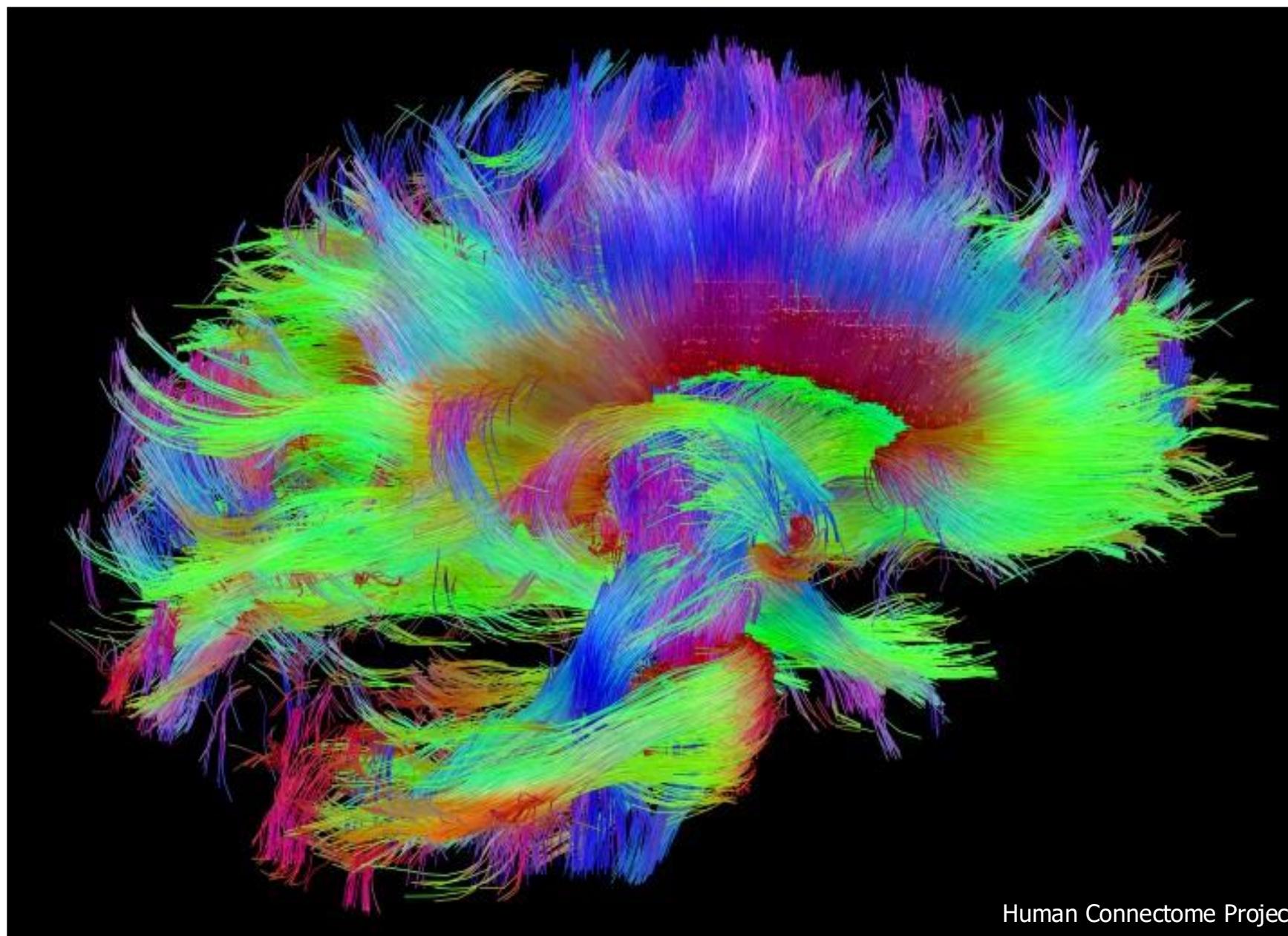
[rainbow\\_hcl\(4\)](#)  
"#E495A5" "#ABB065" "#39BEB1" "#ACA4E2"

[colorspace default\\_palettes](#)  
[diverge\\_hcl](#)  
[diverge\\_hsl](#)  
[terrain\\_hcl](#)  
[sequential\\_hcl](#)  
[rainbow\\_hcl](#)

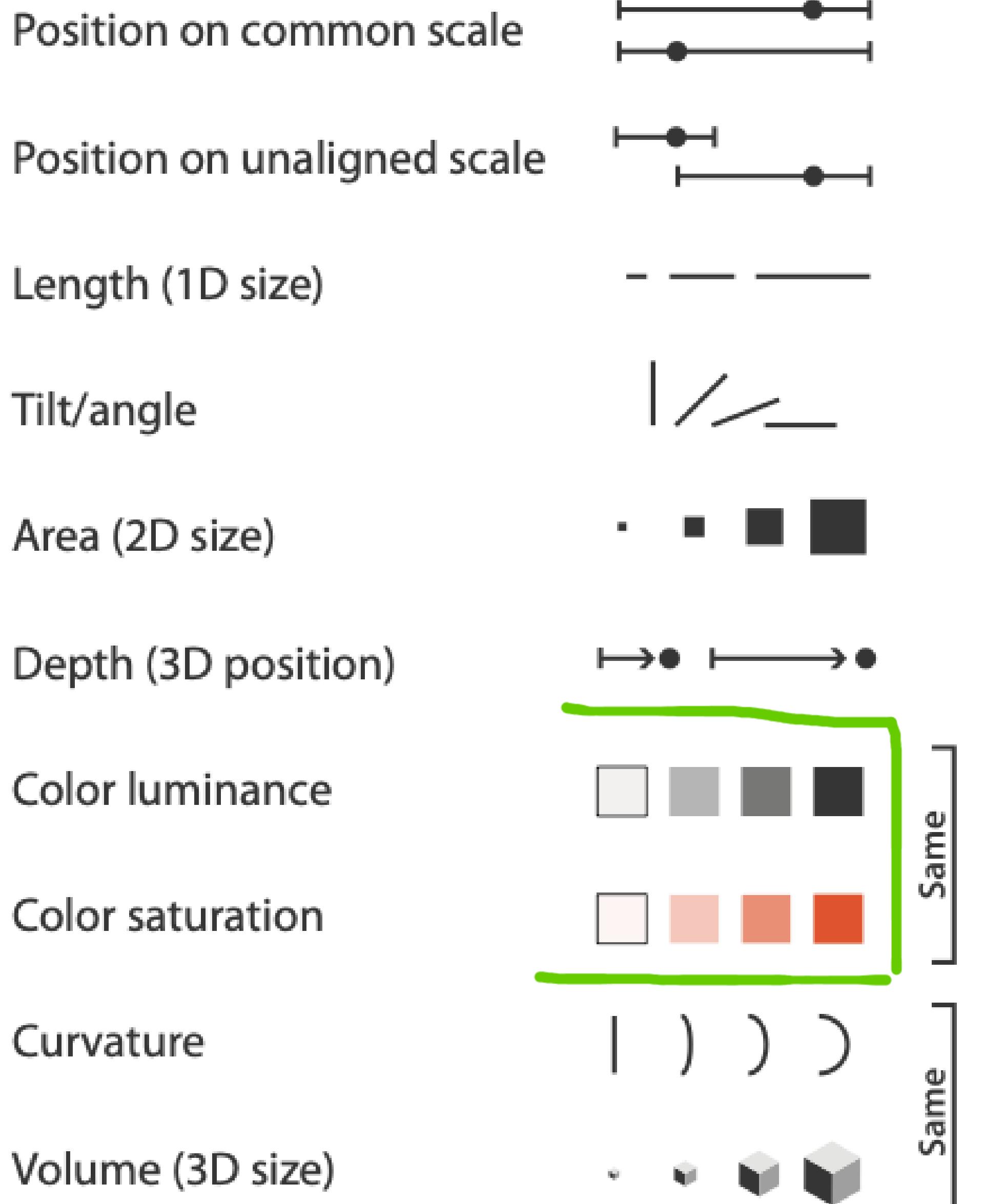
However, all palettes are fully customizable:  
[diverge\\_hcl\(7, h = c\(246, 40\), c = 96, l = c\(65, 90\)\)](#)  
Choosing the values would be daunting. But there are some recommended palettes in the colorspace documentation. There is also an interactive tool that can be used to obtain a customized palette. To start the tool:  
[pal <- choose\\_palette\(\)](#)

# Escalas y paletas de Color

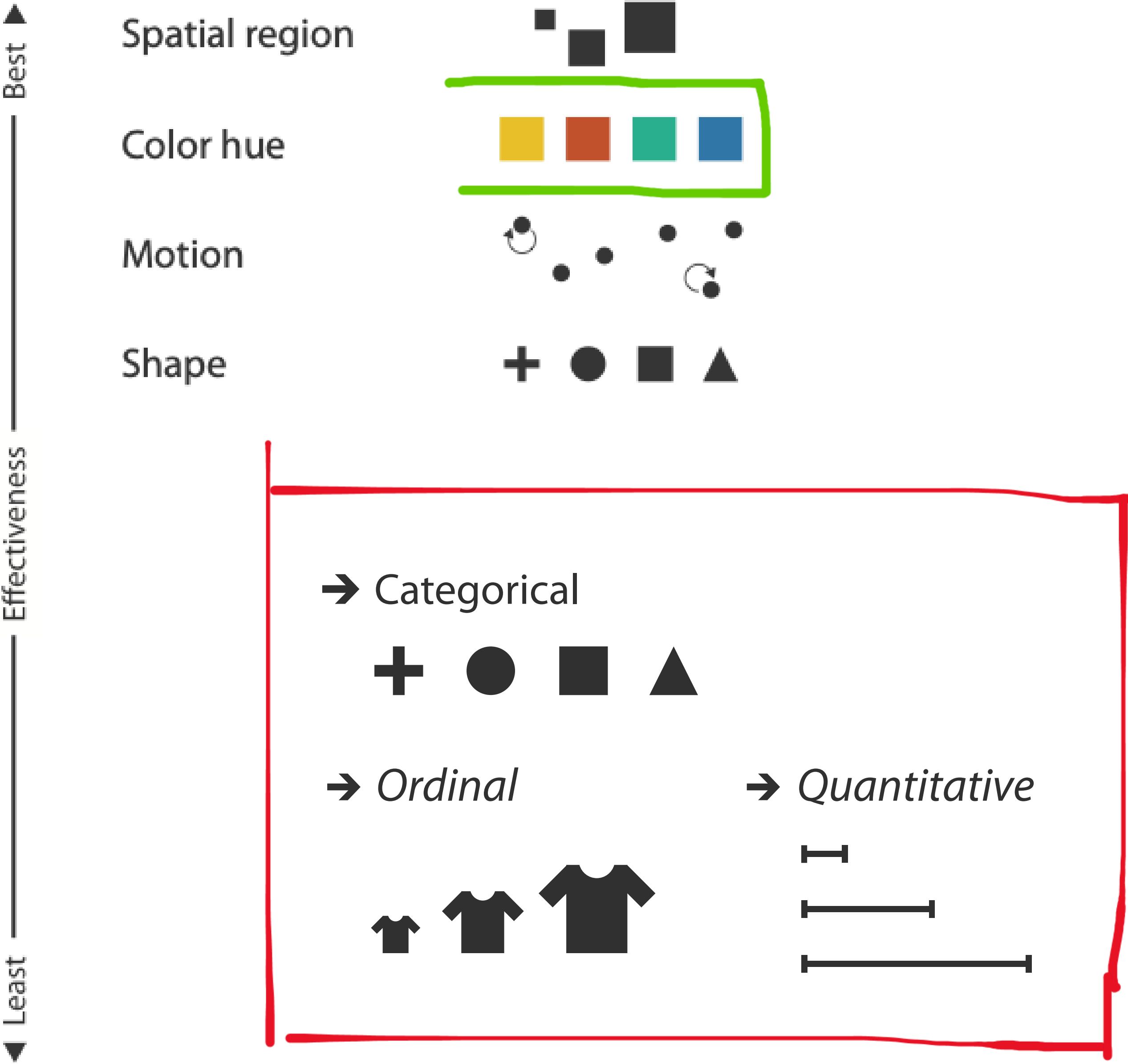
## Colorear datos



## → **Magnitude Channels: Ordered Attributes**

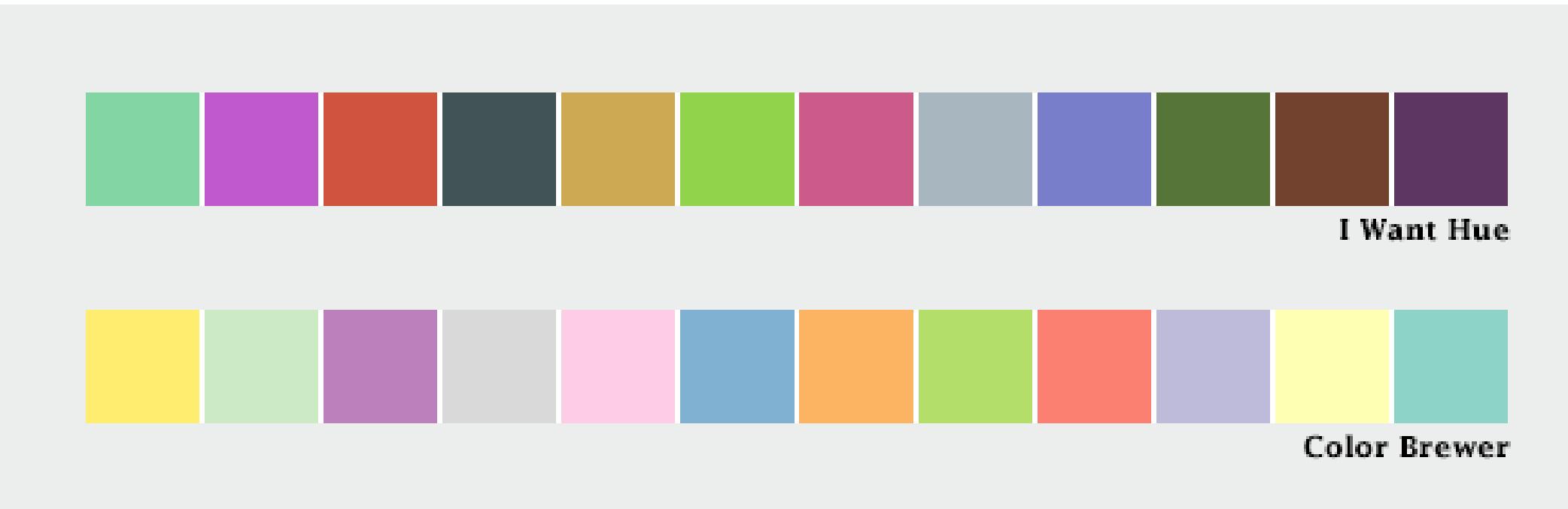


## → **Identity Channels: Categorical Attributes**



# Colorear datos -> Color palette/scheme/scale

Categórica/Cualitativa



➡ Ordering Direction

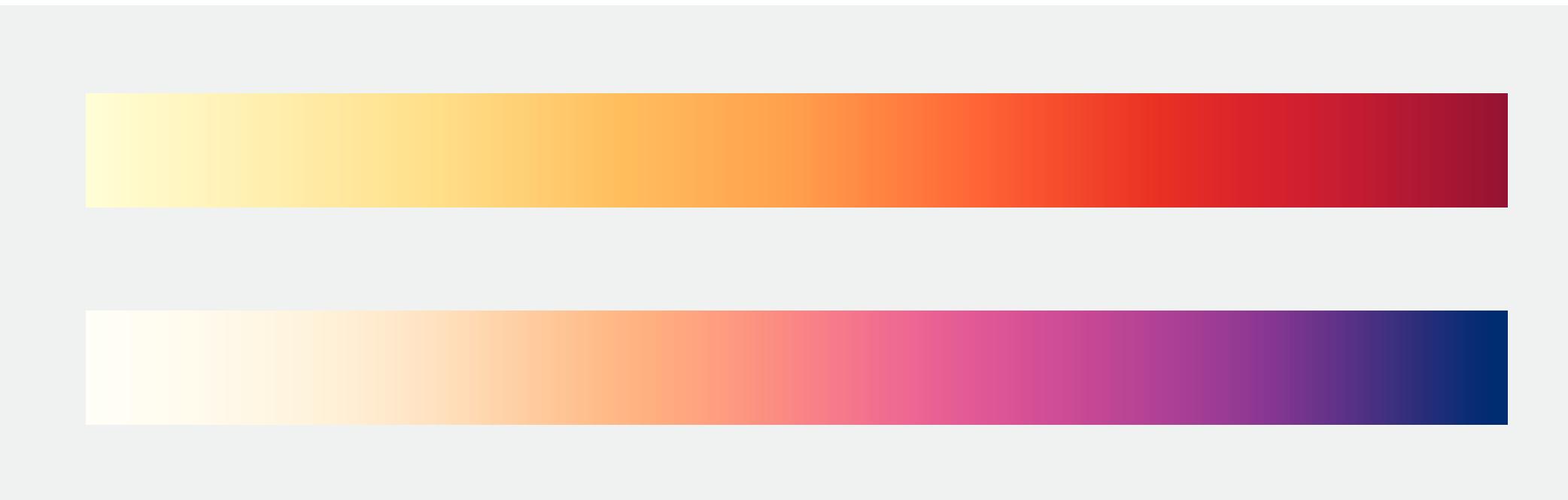
→ Sequential



→ Diverging



Secuencial

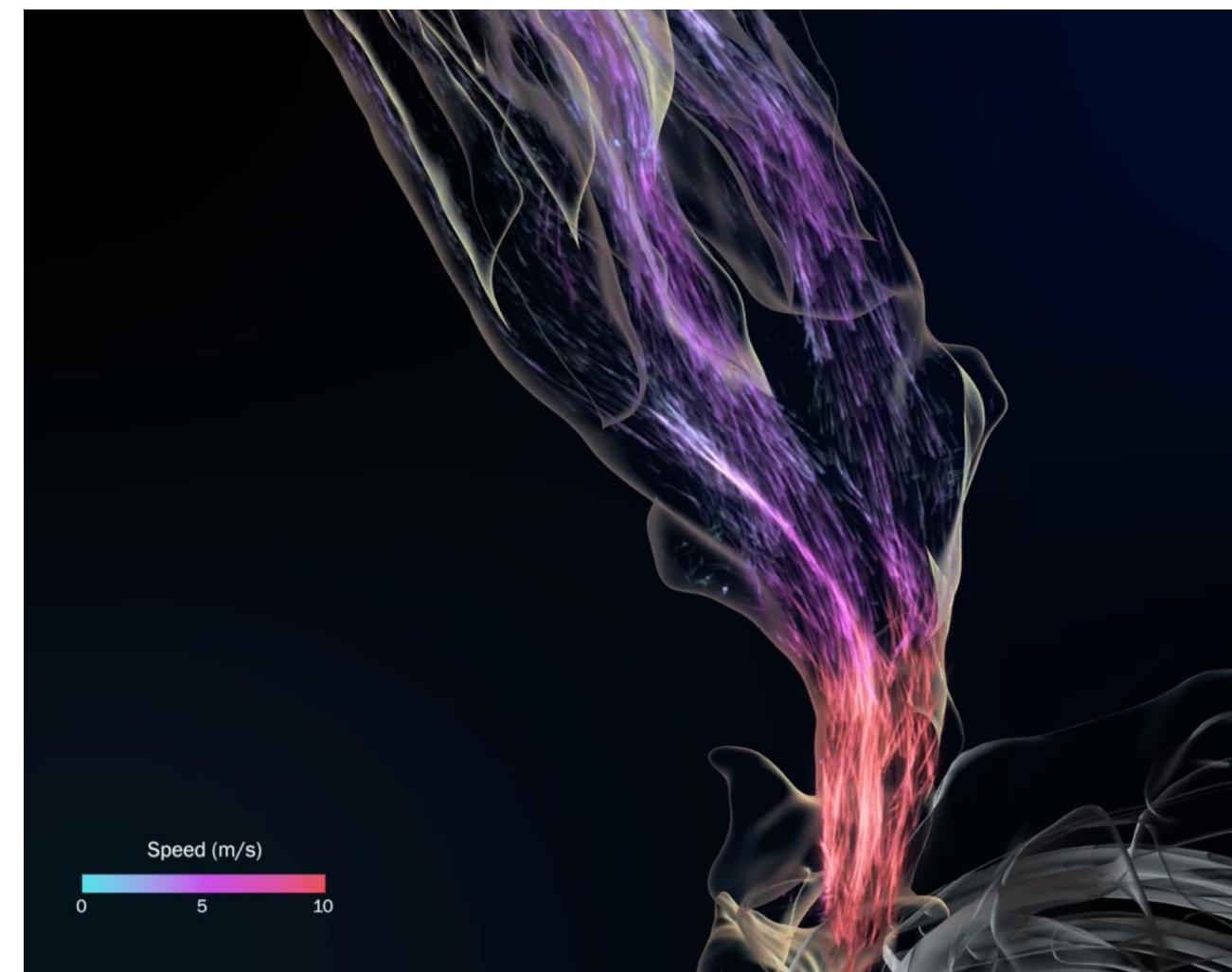


Divergente

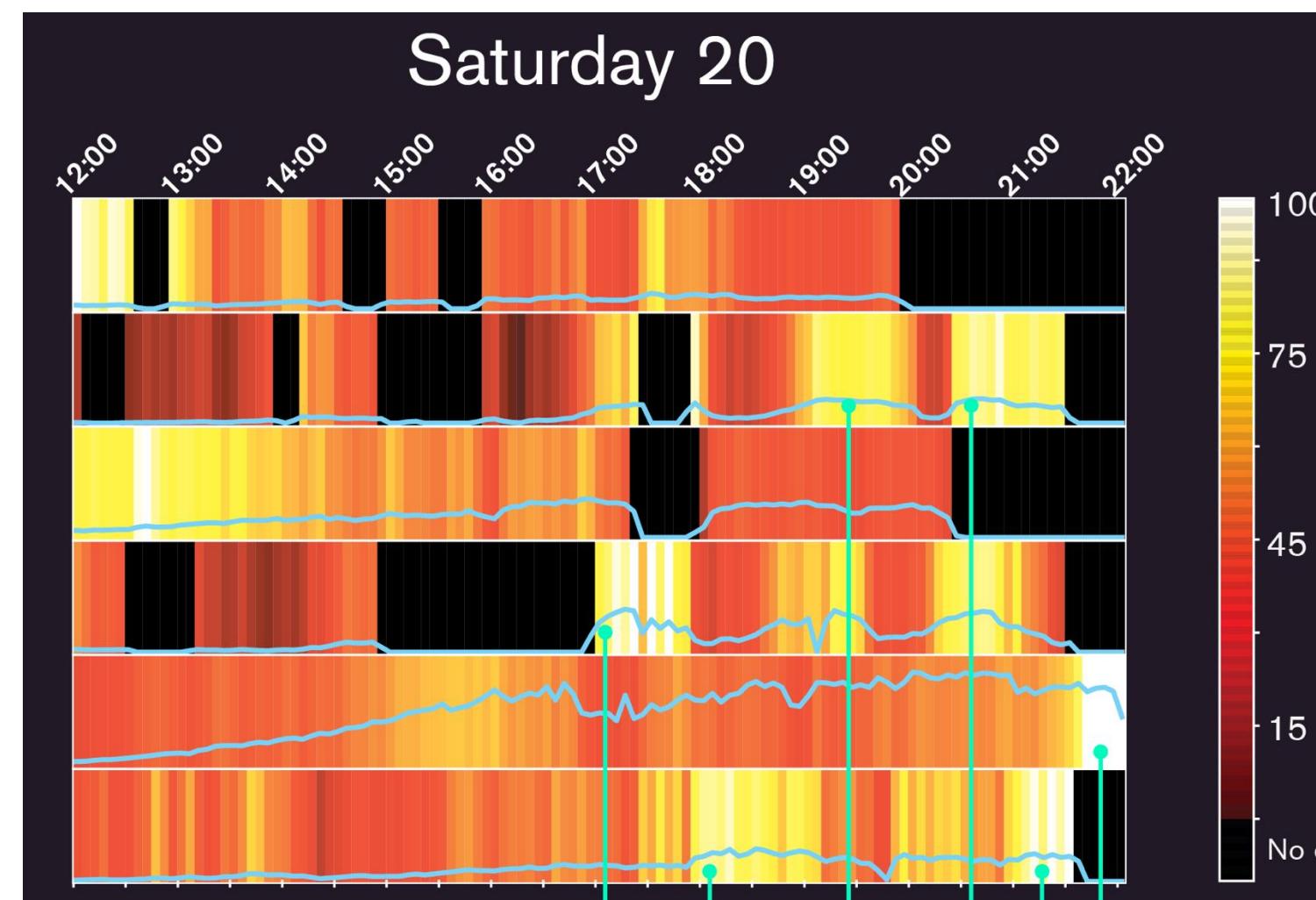


# Cuantitativo Secuencial

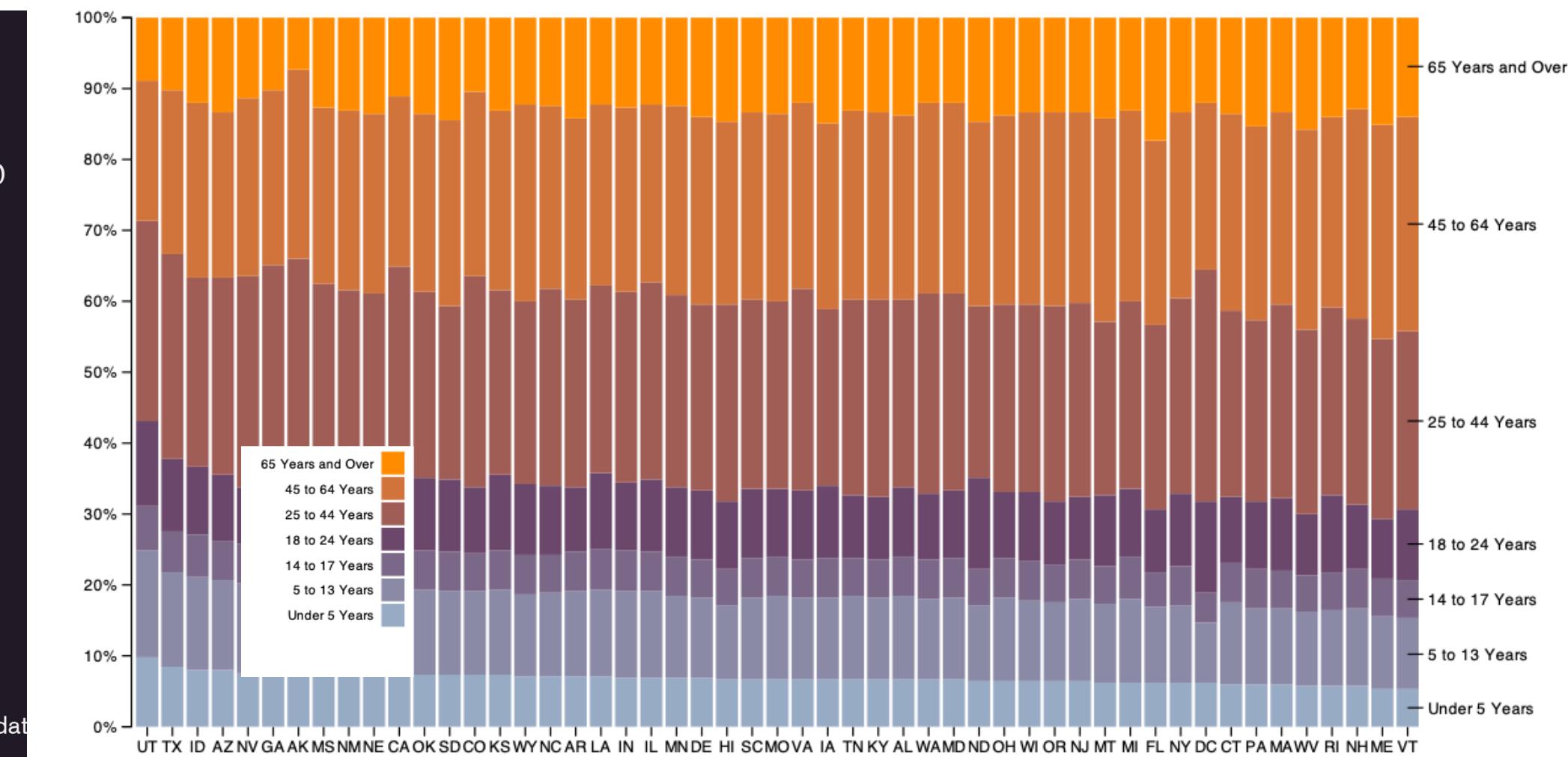
Continua



Discretizada

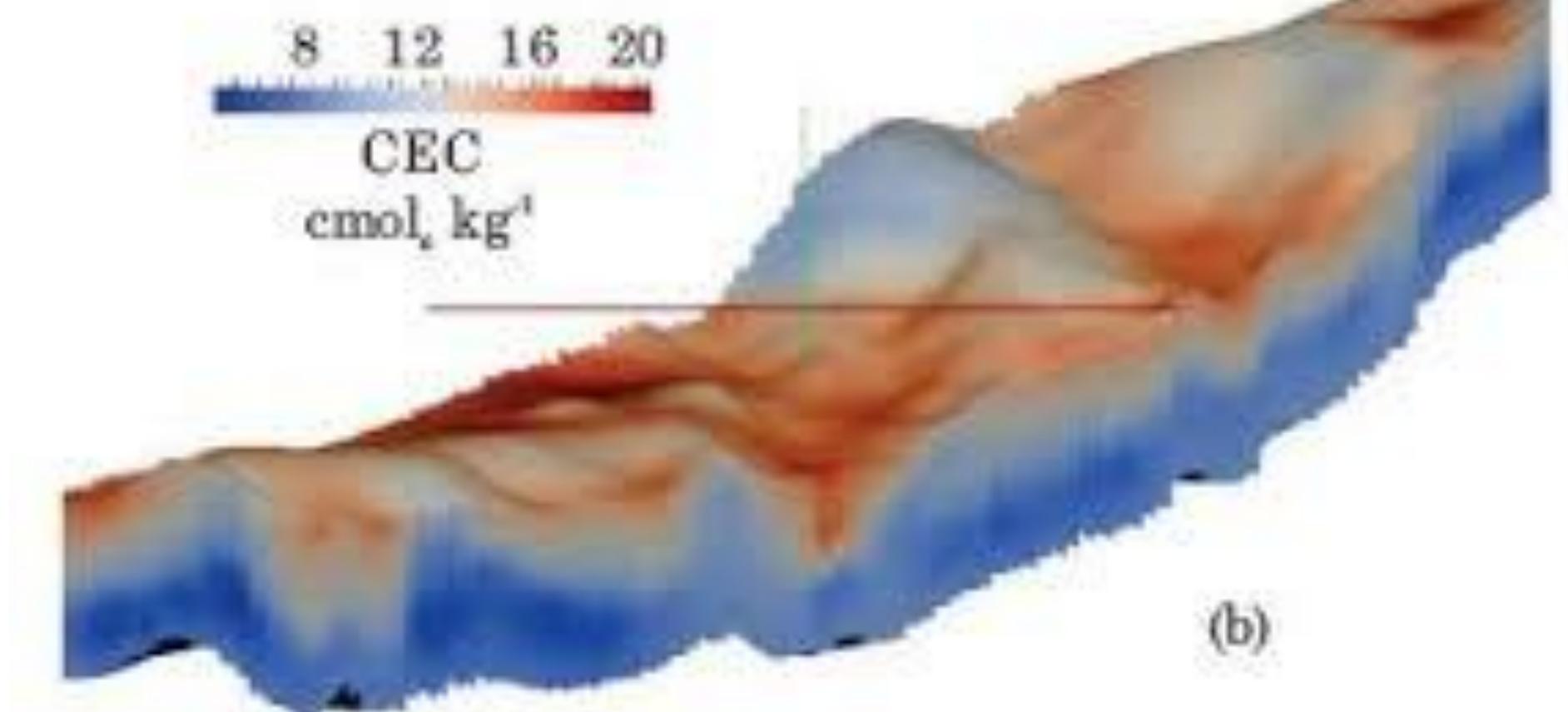


Ordinal = Continua discretizada

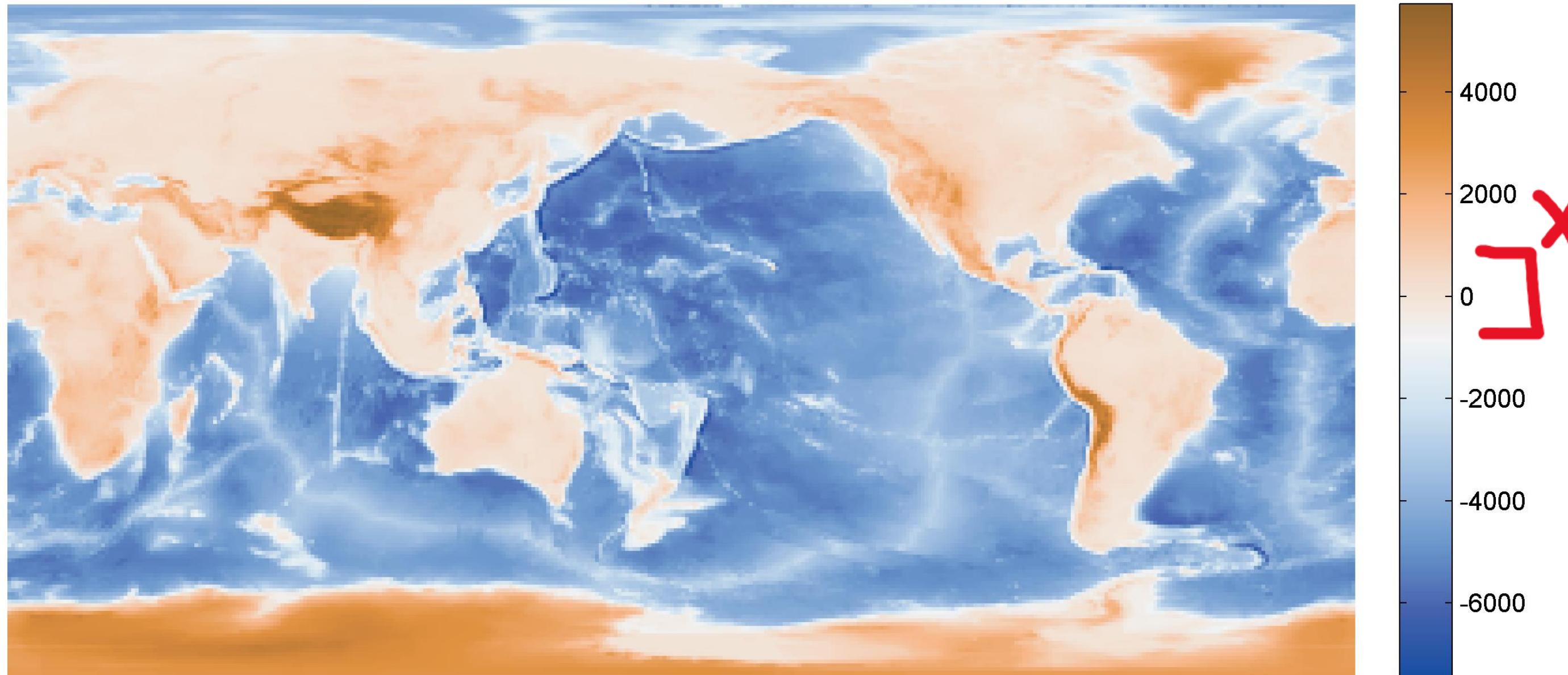


# Cuantitativo Divergente

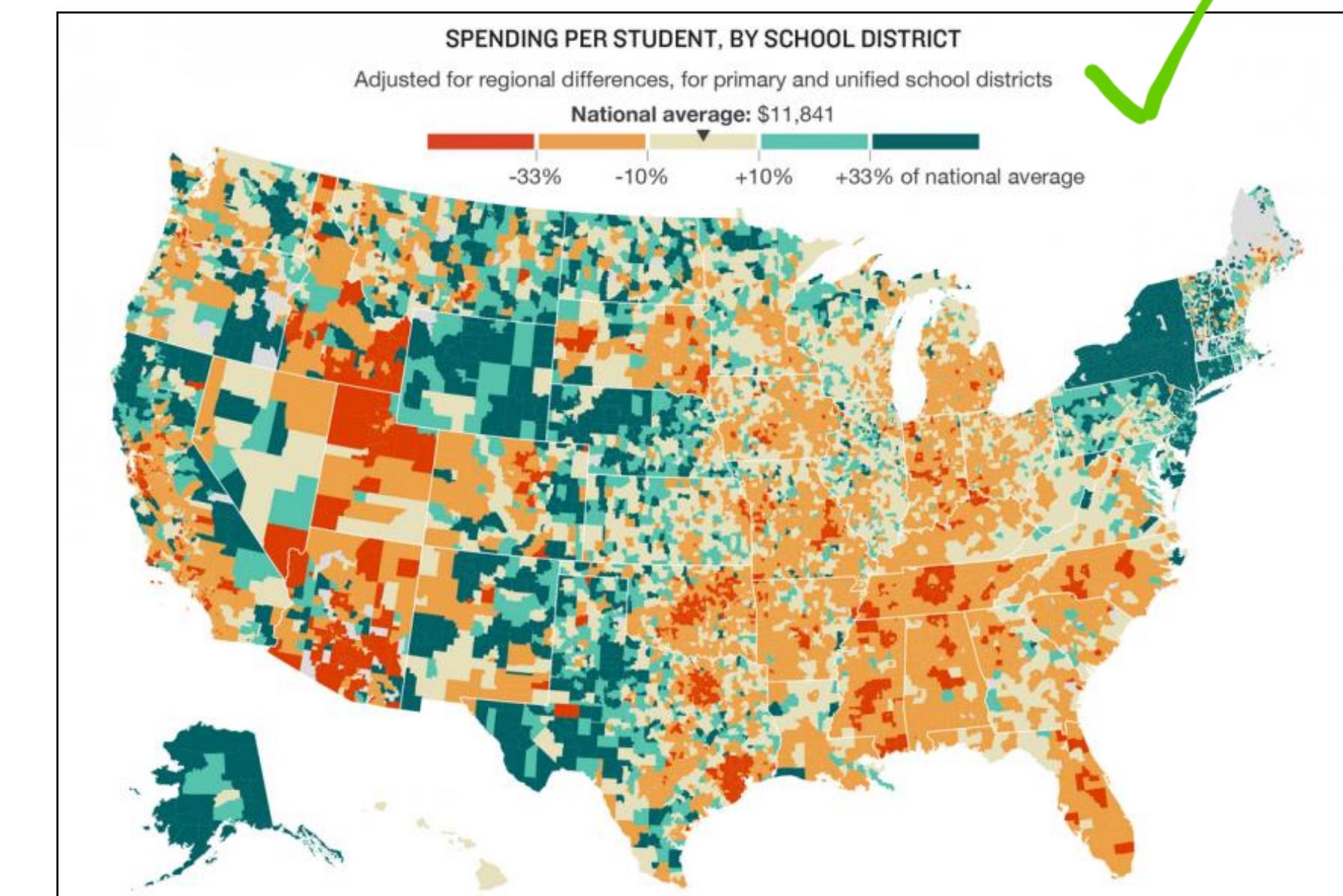
Es importante que el color central (normalmente blanco) represente el valor central en los datos (normalmente 0)



Continua

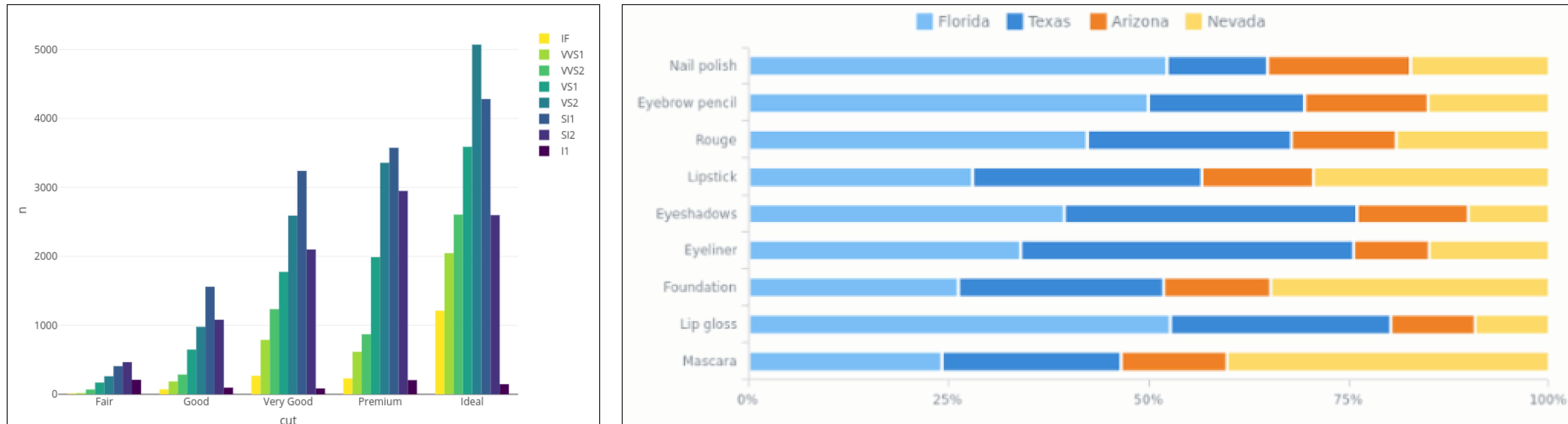


Discretizada



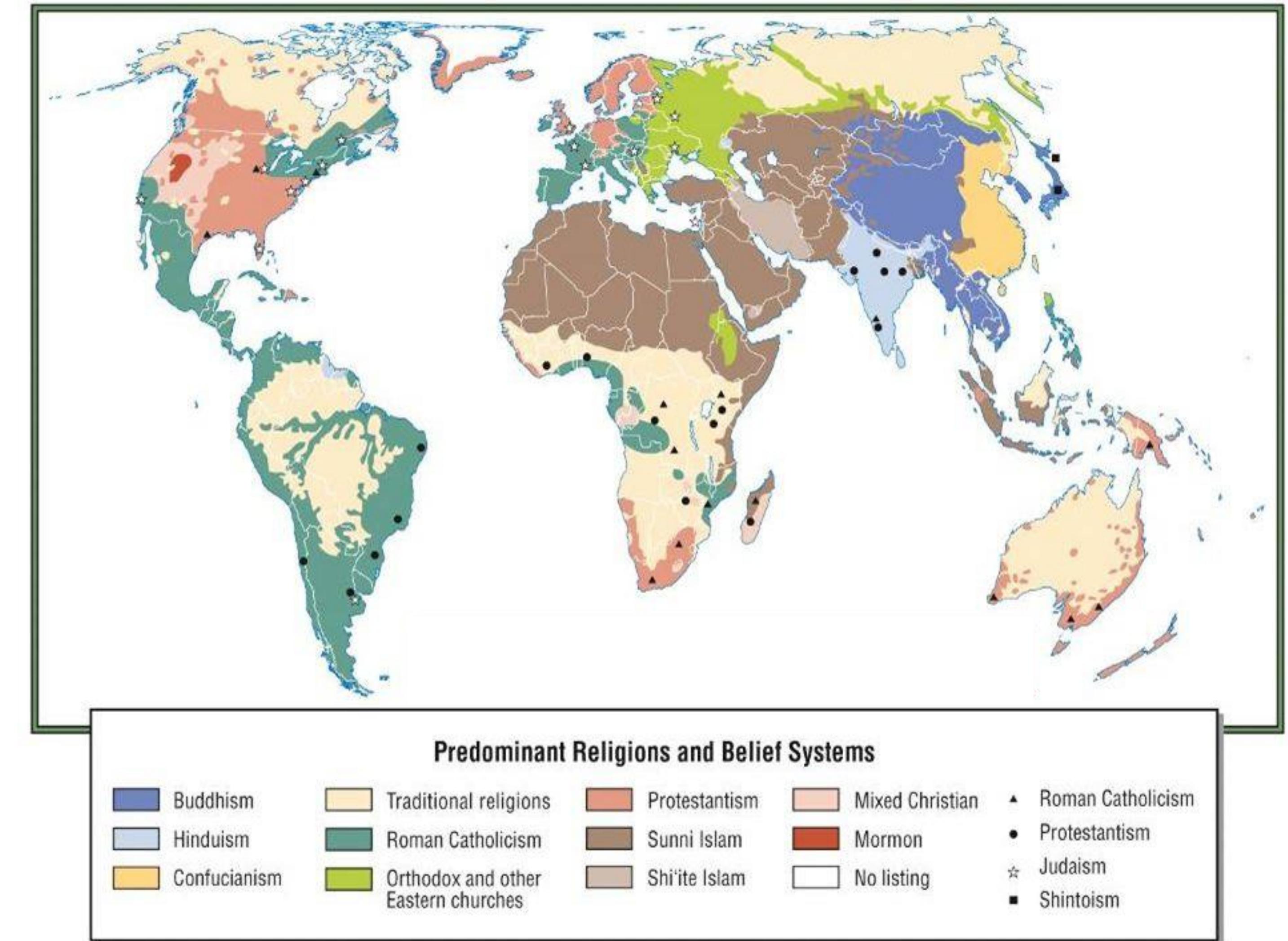
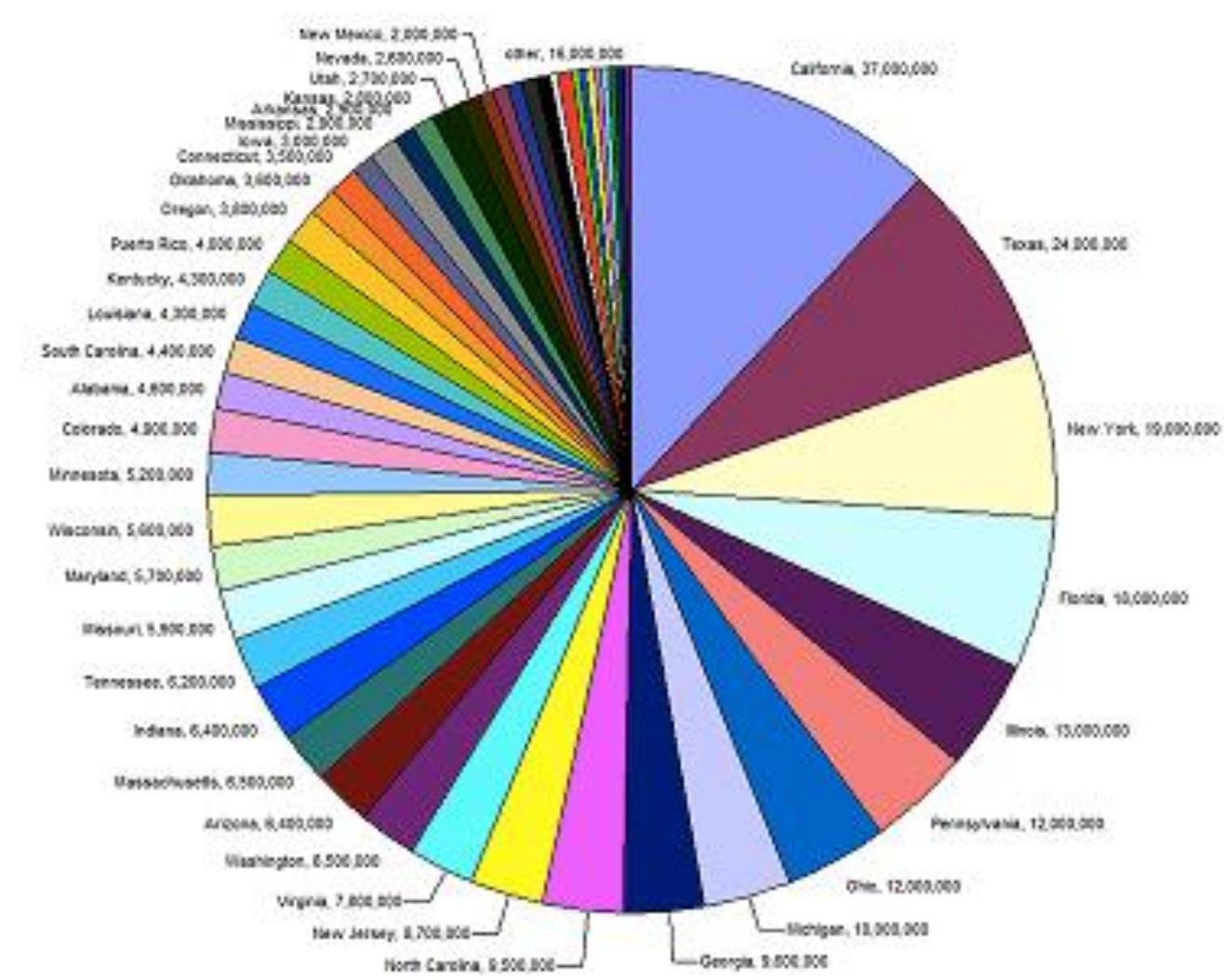
# Categoría

Cuidado con colores que formen un gradiente continuo, pueden confundirse con valores ordinales  
Casi siempre es mejor diferencias grandes en tono, saturación, y/o luminosidad



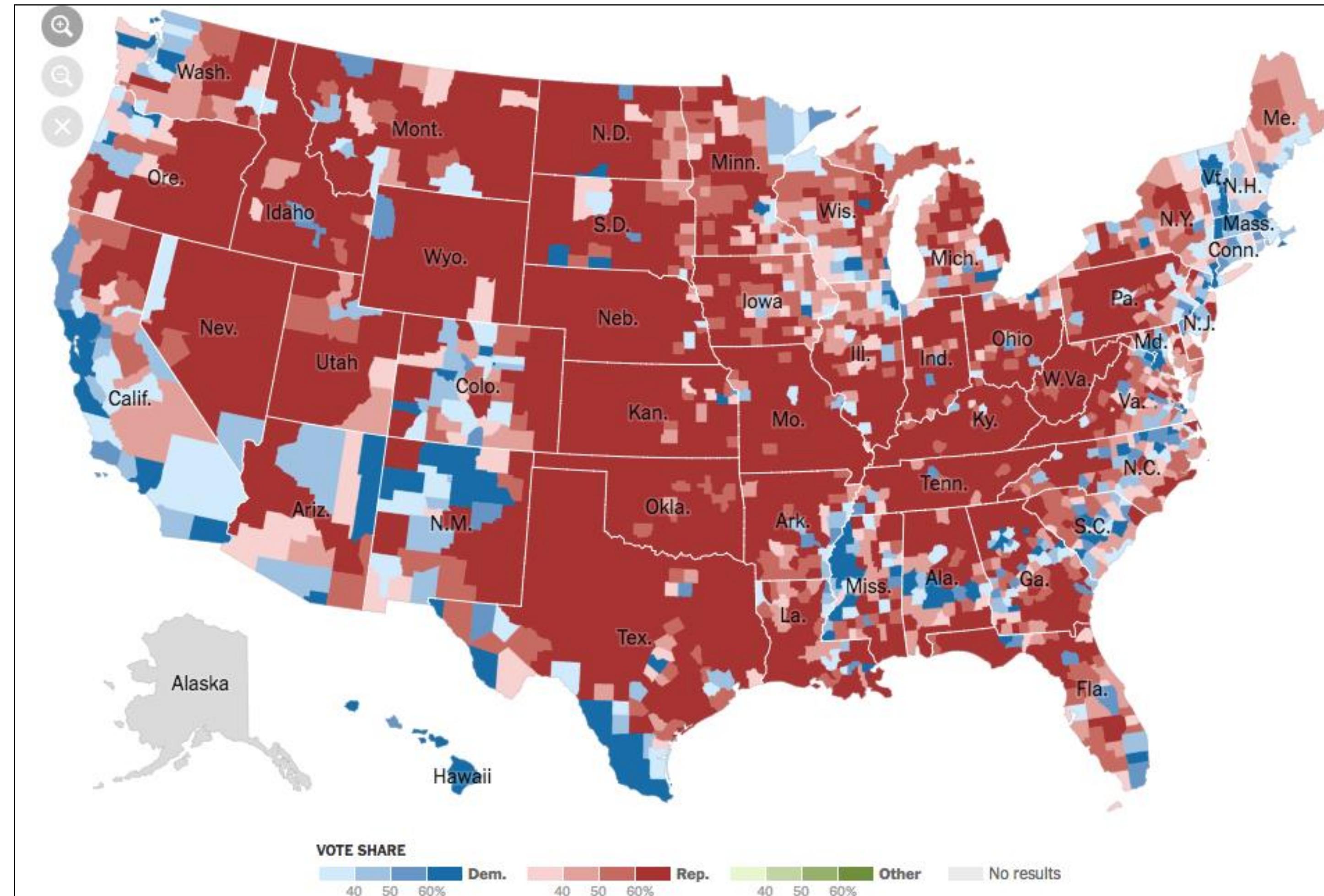
# Categórica

No demasiados colores (max. 12)



# Agrupado

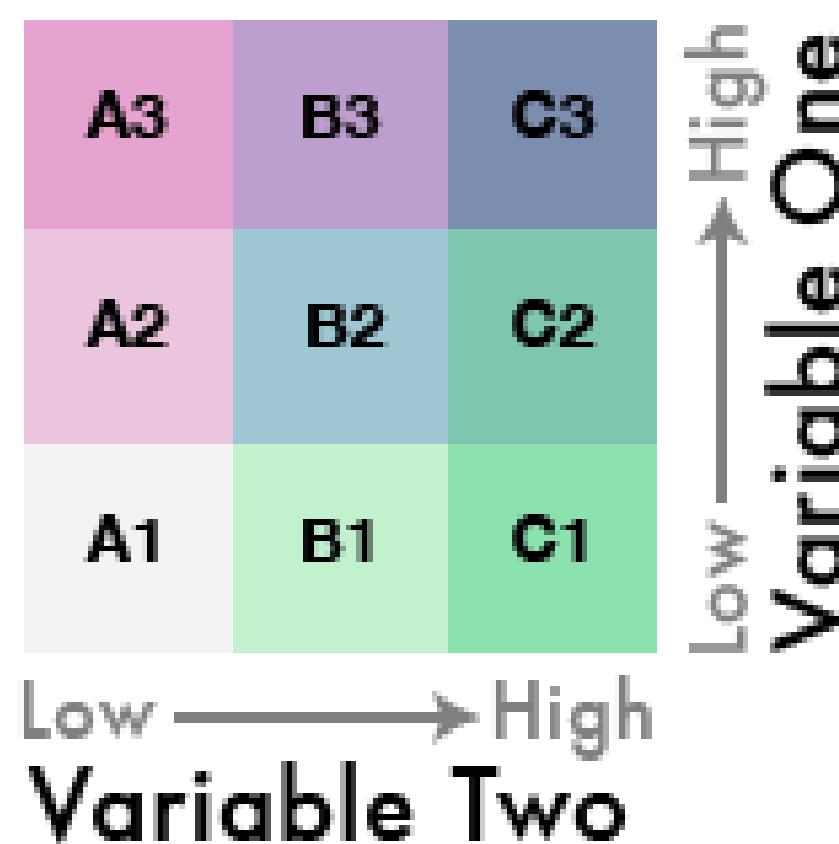
Esquema de color agrupado de 4 categorías (4 tonos), con 4 pasos de saturación y luminosidad cada uno



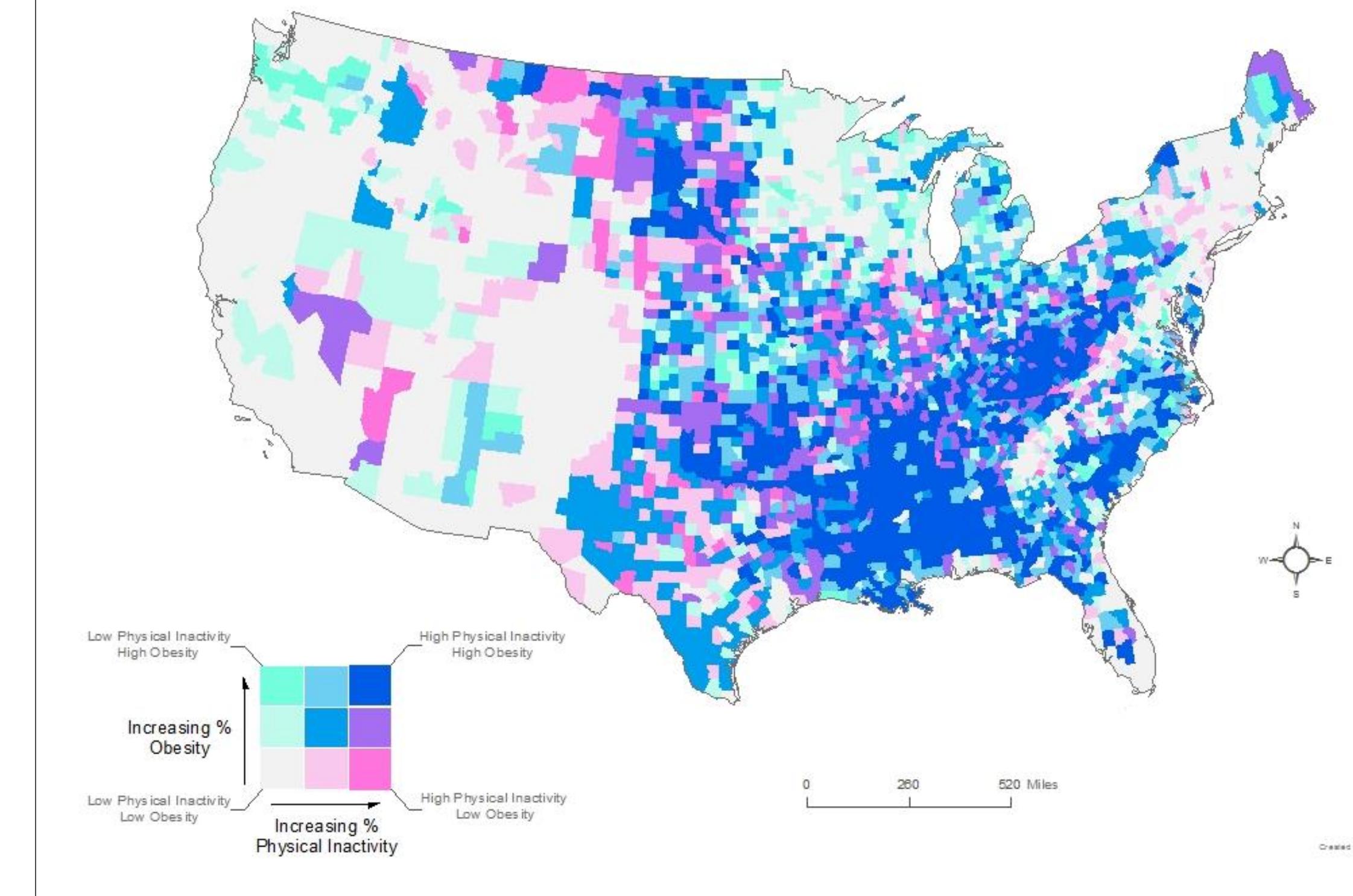
# Bi-variate choropleth maps

Esquema de color con dos escalas sobreuestas en dos direcciones.

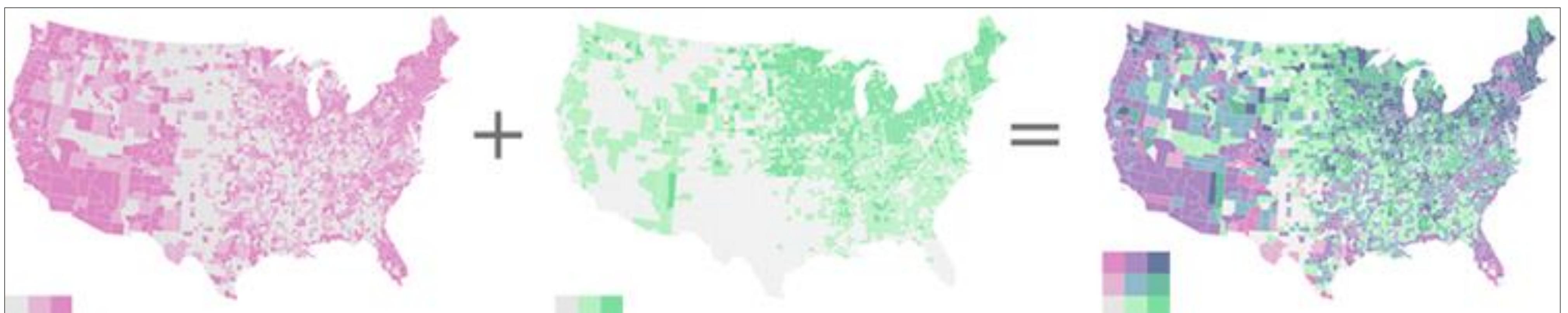
Normalmente resulta una matriz de 3x3



## The Effects of Physical Inactivity on Obesity

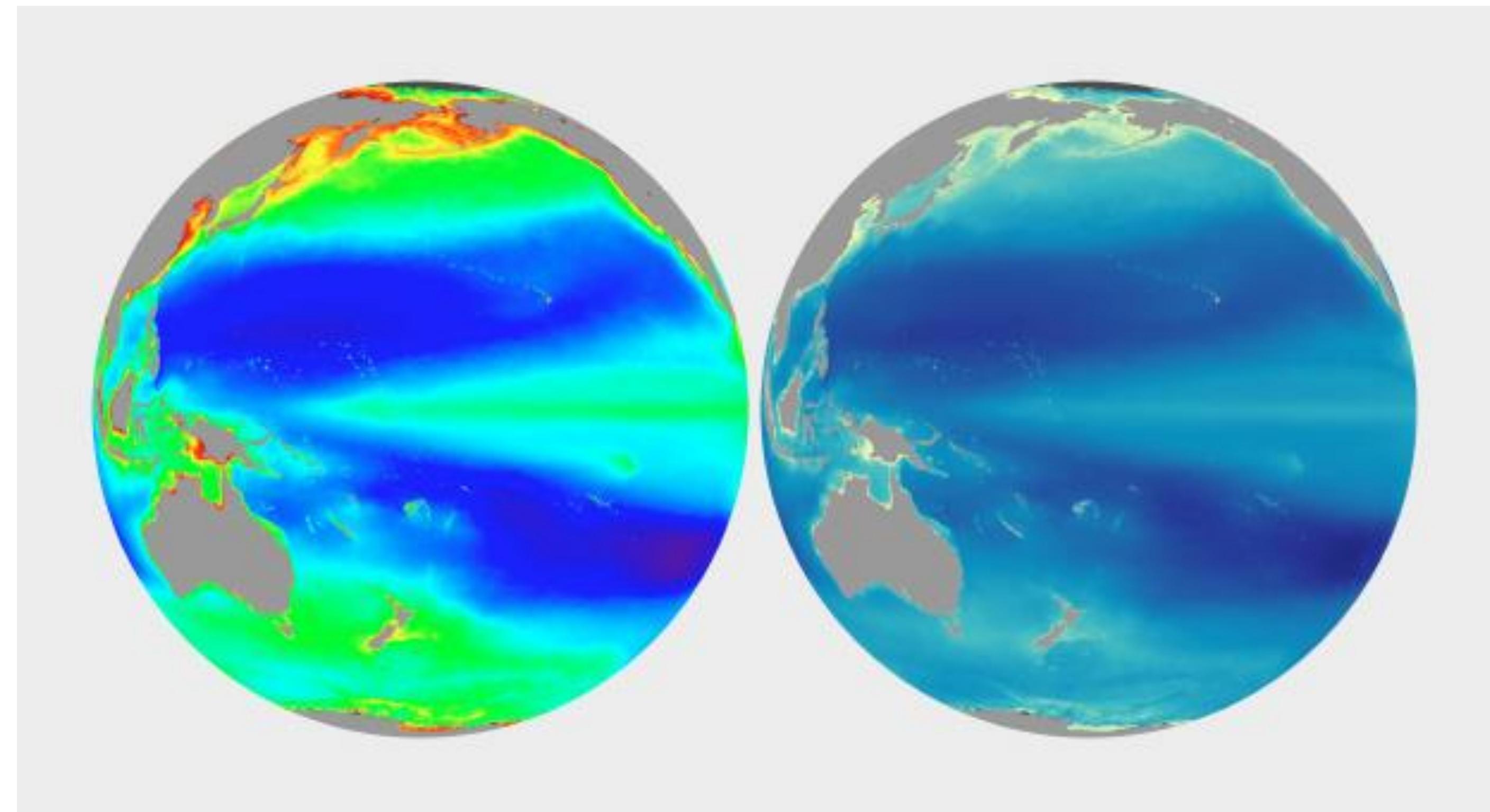
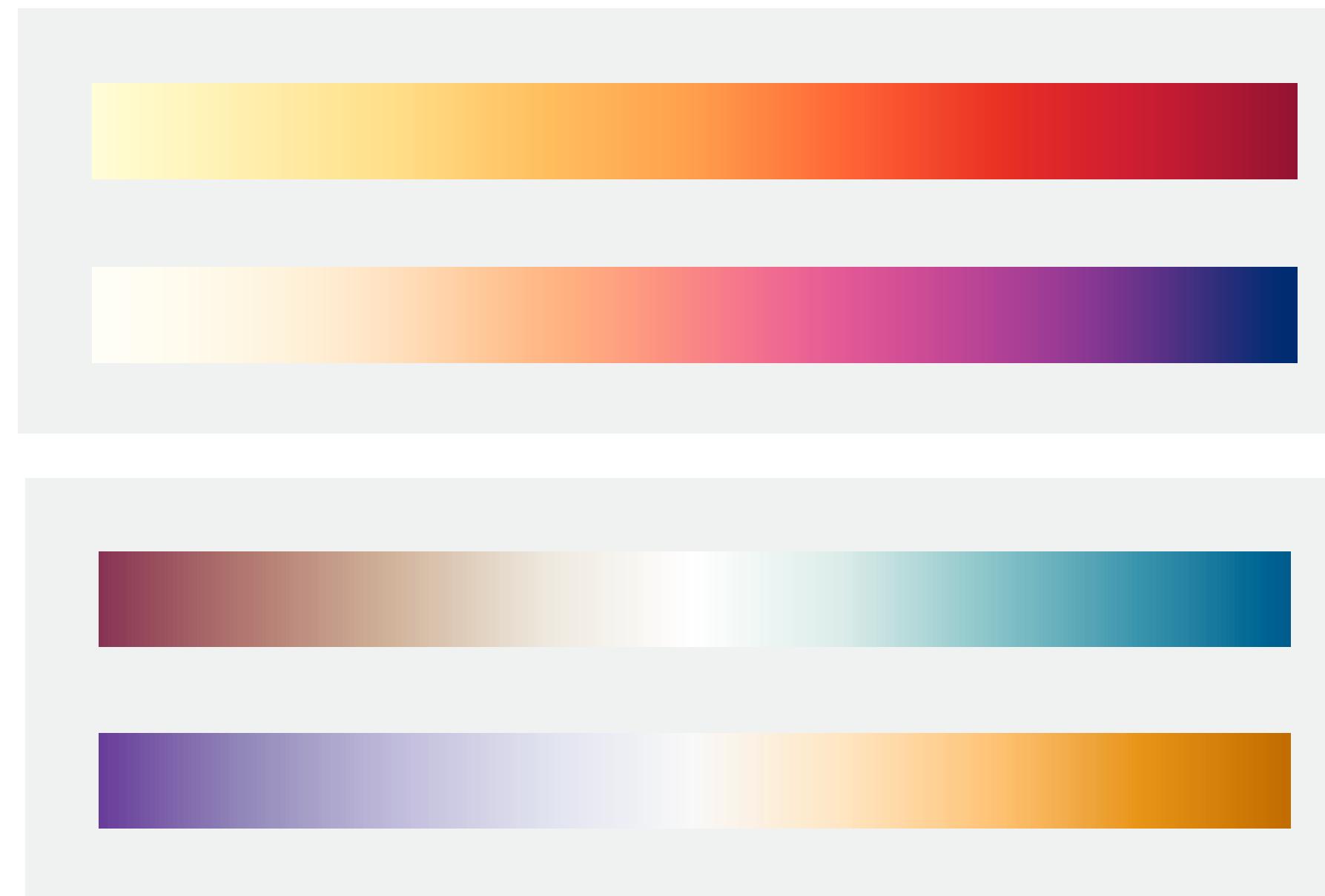


Joshua Stevens, from: [www.joshuastevens.net](http://www.joshuastevens.net)



## Perceptually linear scales

- Cuidado al usar presets
- Una escala de color adecuada debe variar de forma consistente a través del rango de valores
- Usar escalas **perceptualmente correctas**

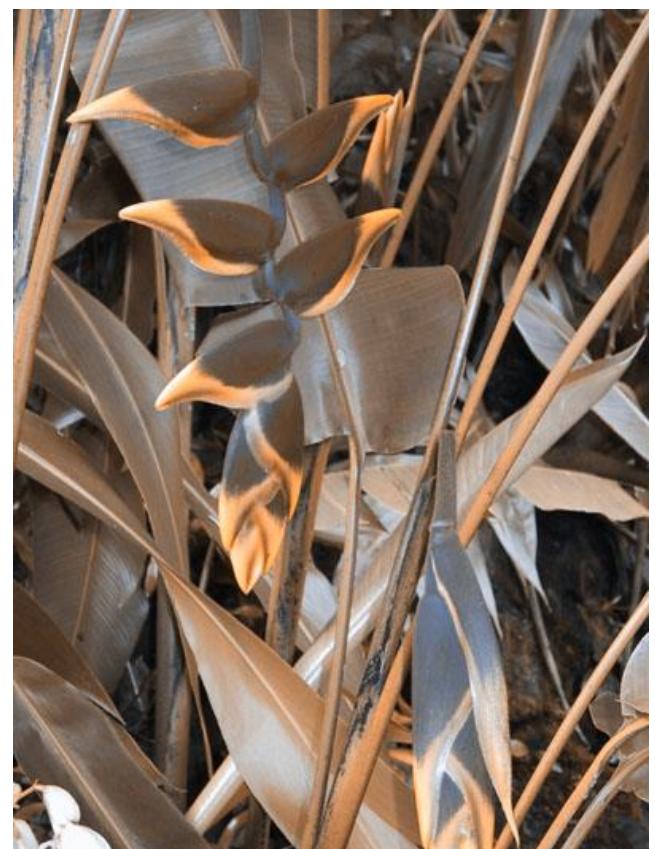


Simmon, 2013

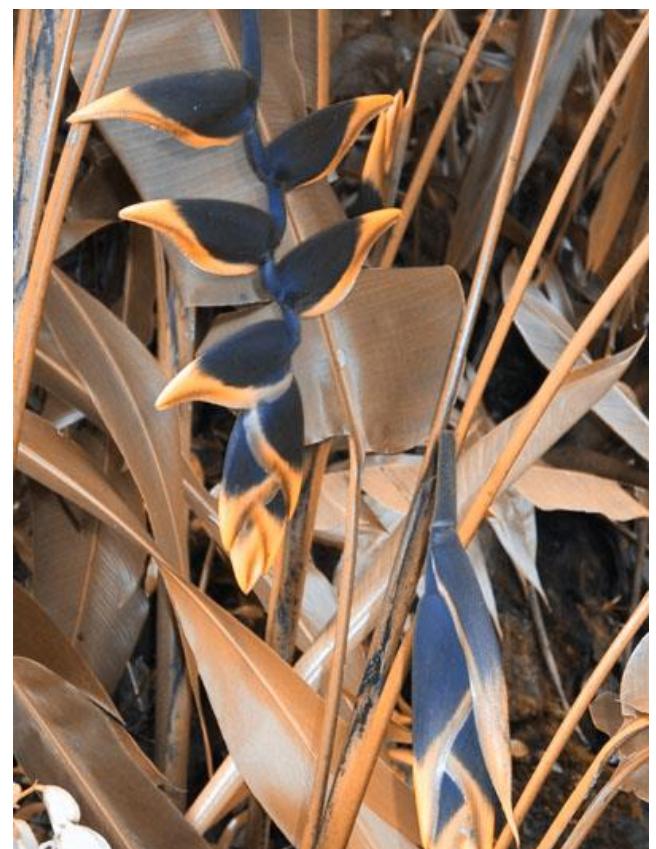
# Diseñar para color deficiency: Usar simuladores



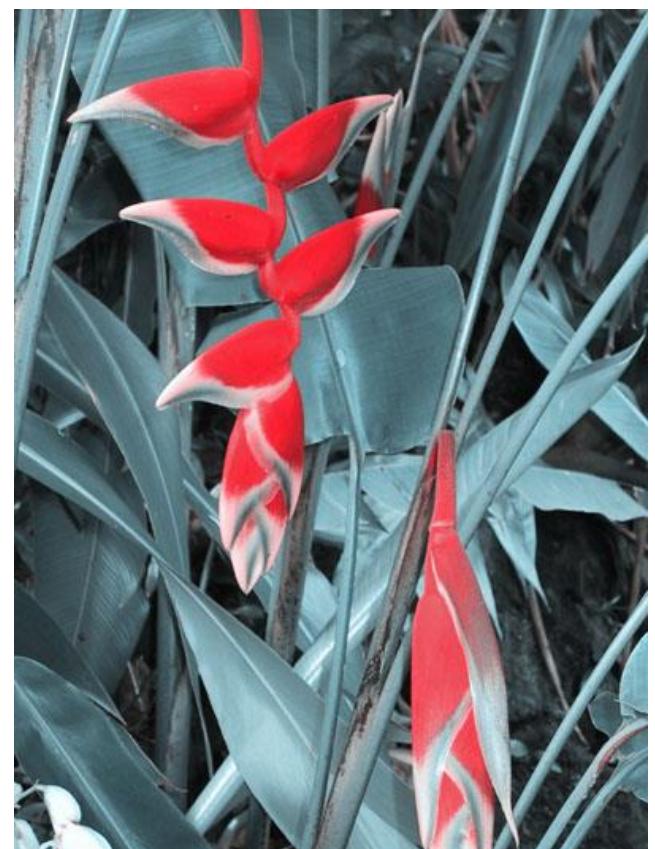
Normal vision



Deutanope



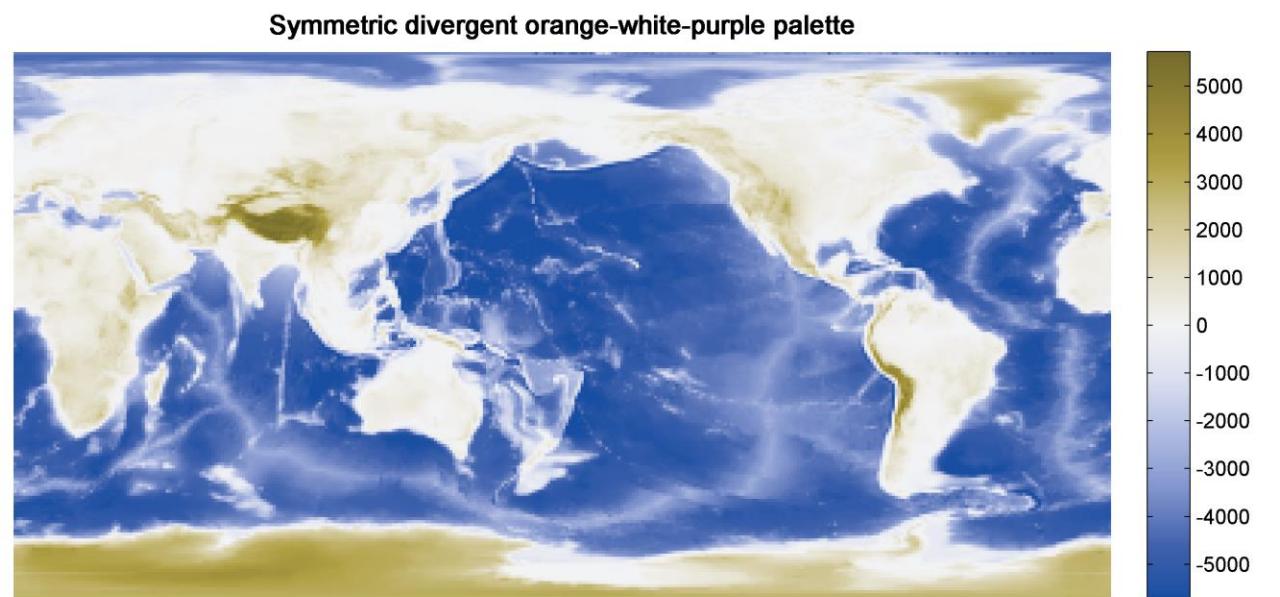
Protanope



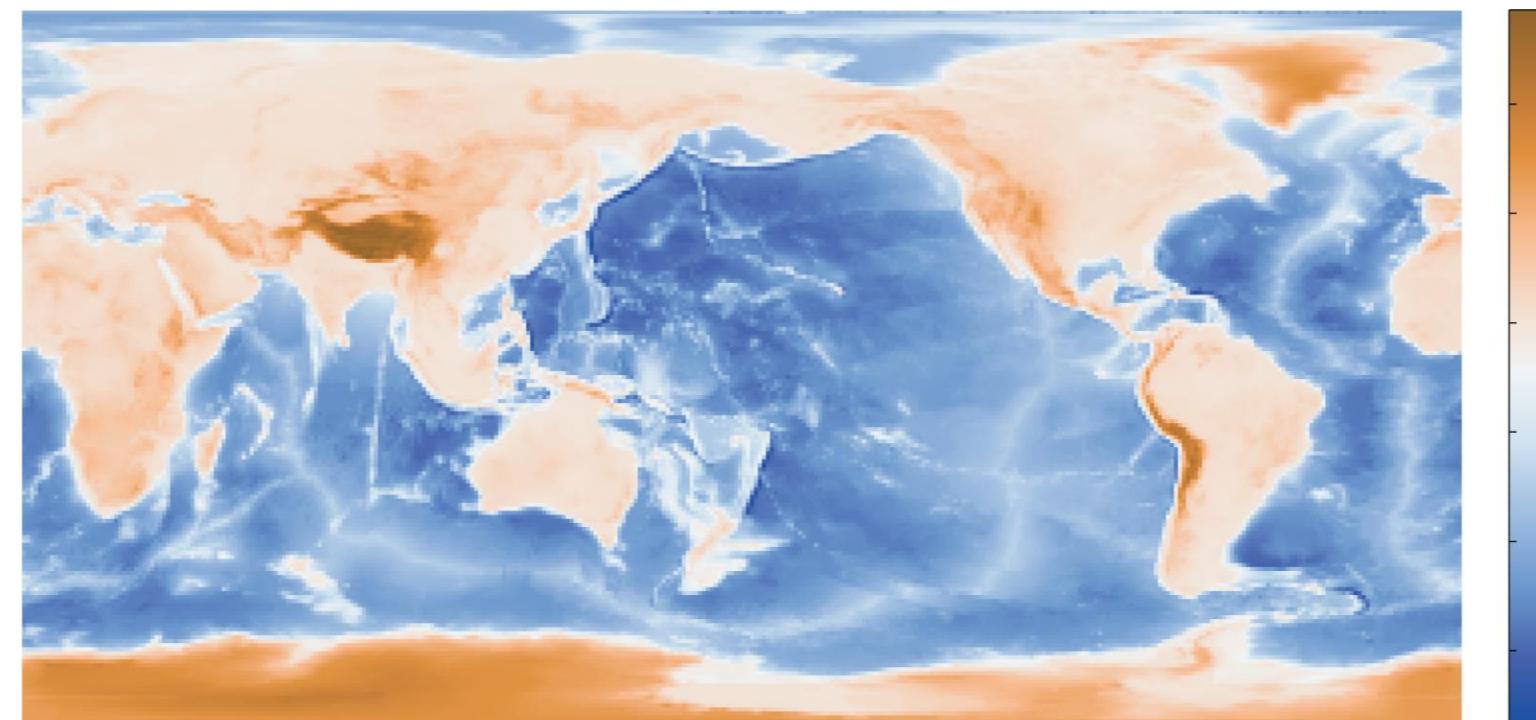
Tritanope

[Seriously Colorful: Advanced Color Principles & Practices. Stone.Tableau Customer Conference 2014.]

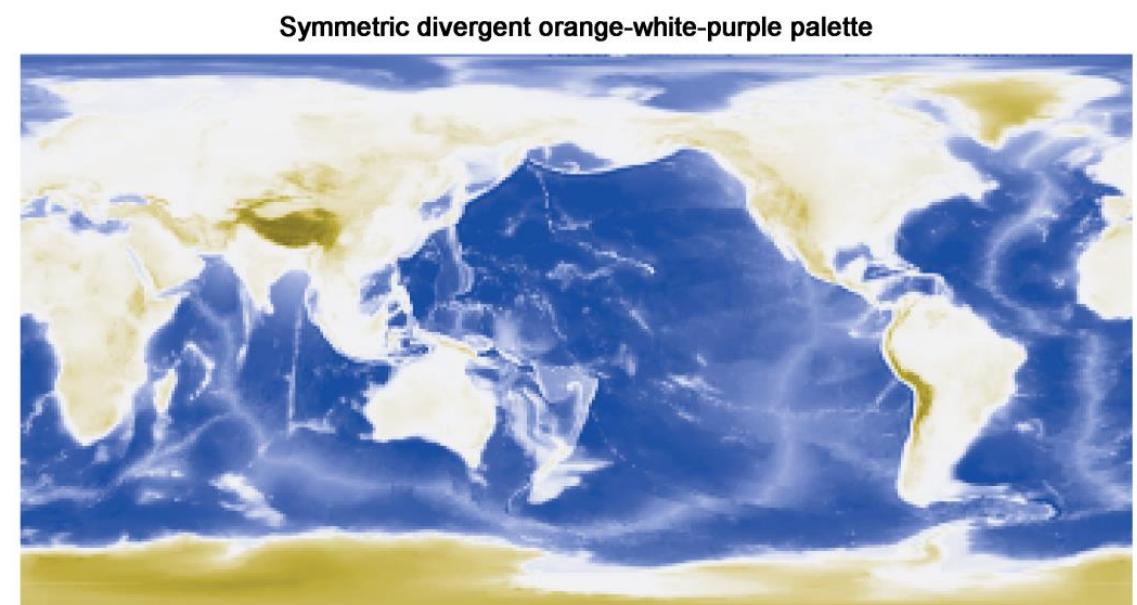
Protanope



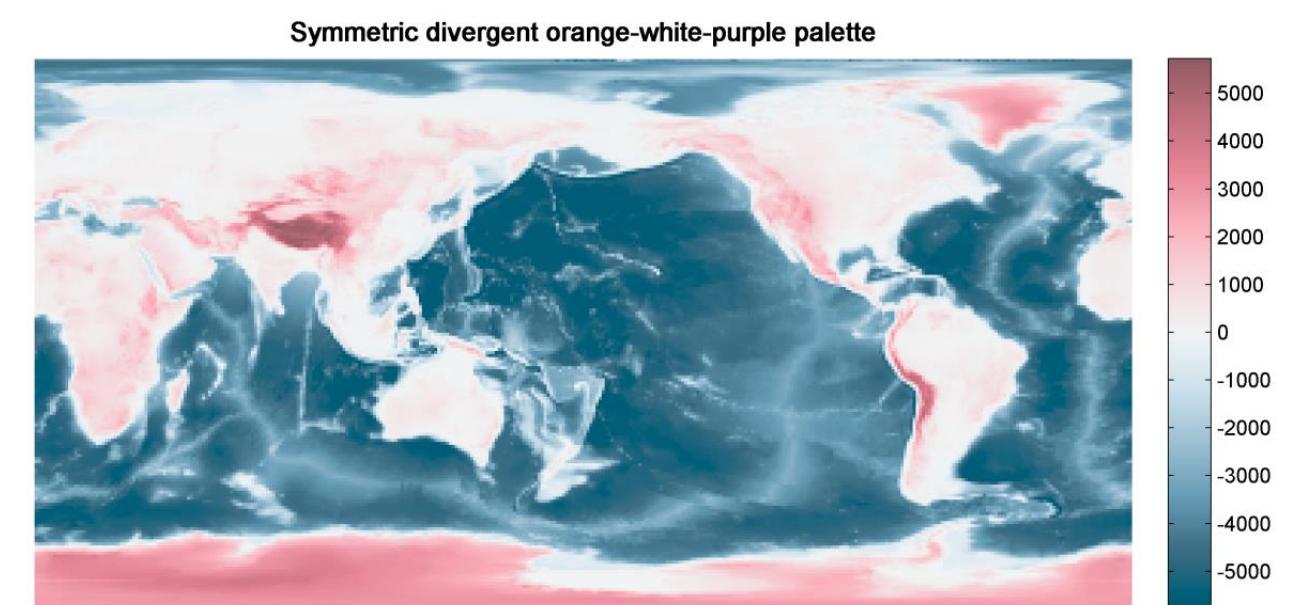
Non-symmetric divergent orange-white-purple palette



Deutanope

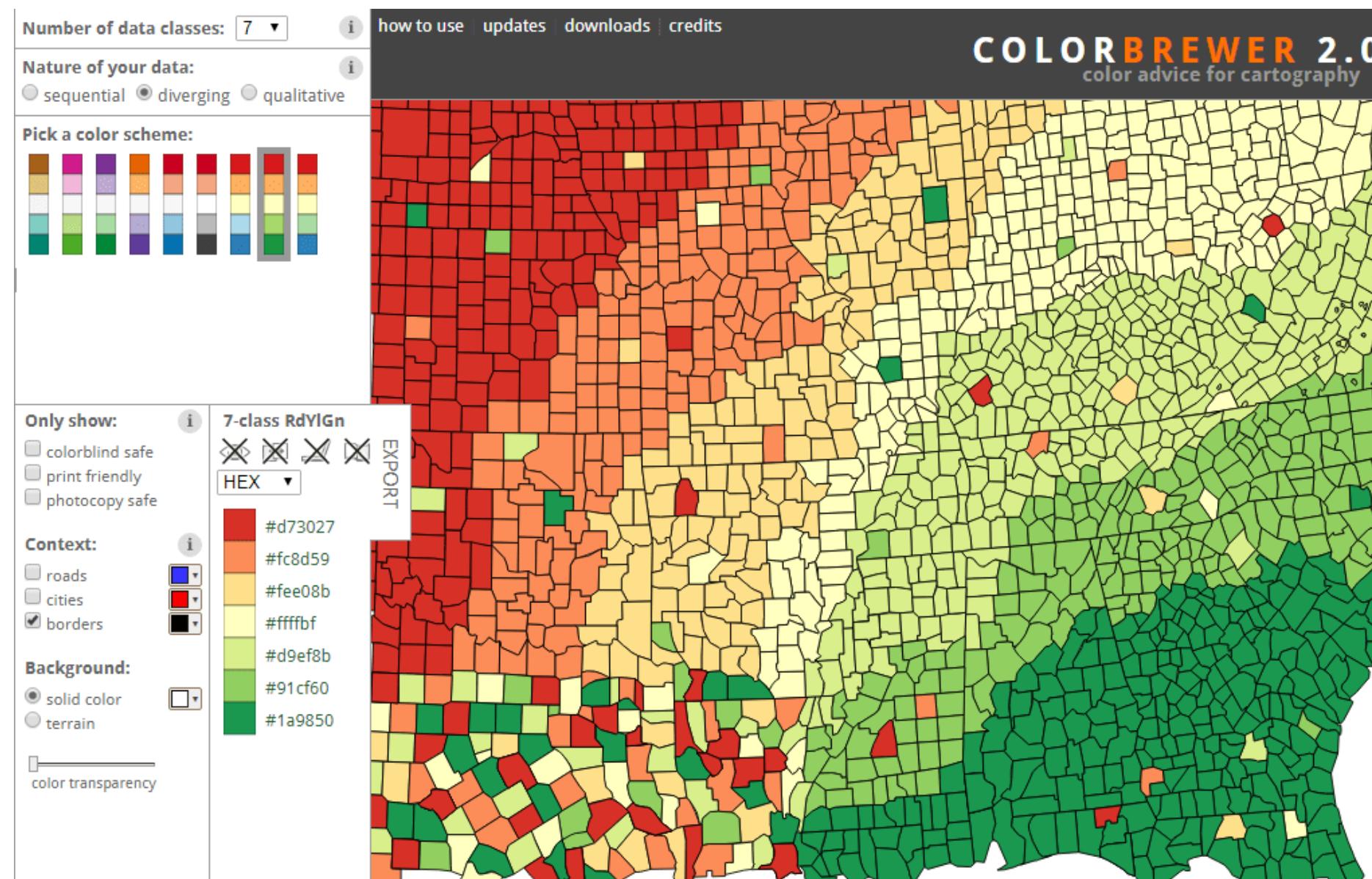


Tritanope



# Simuladores de color deficiency

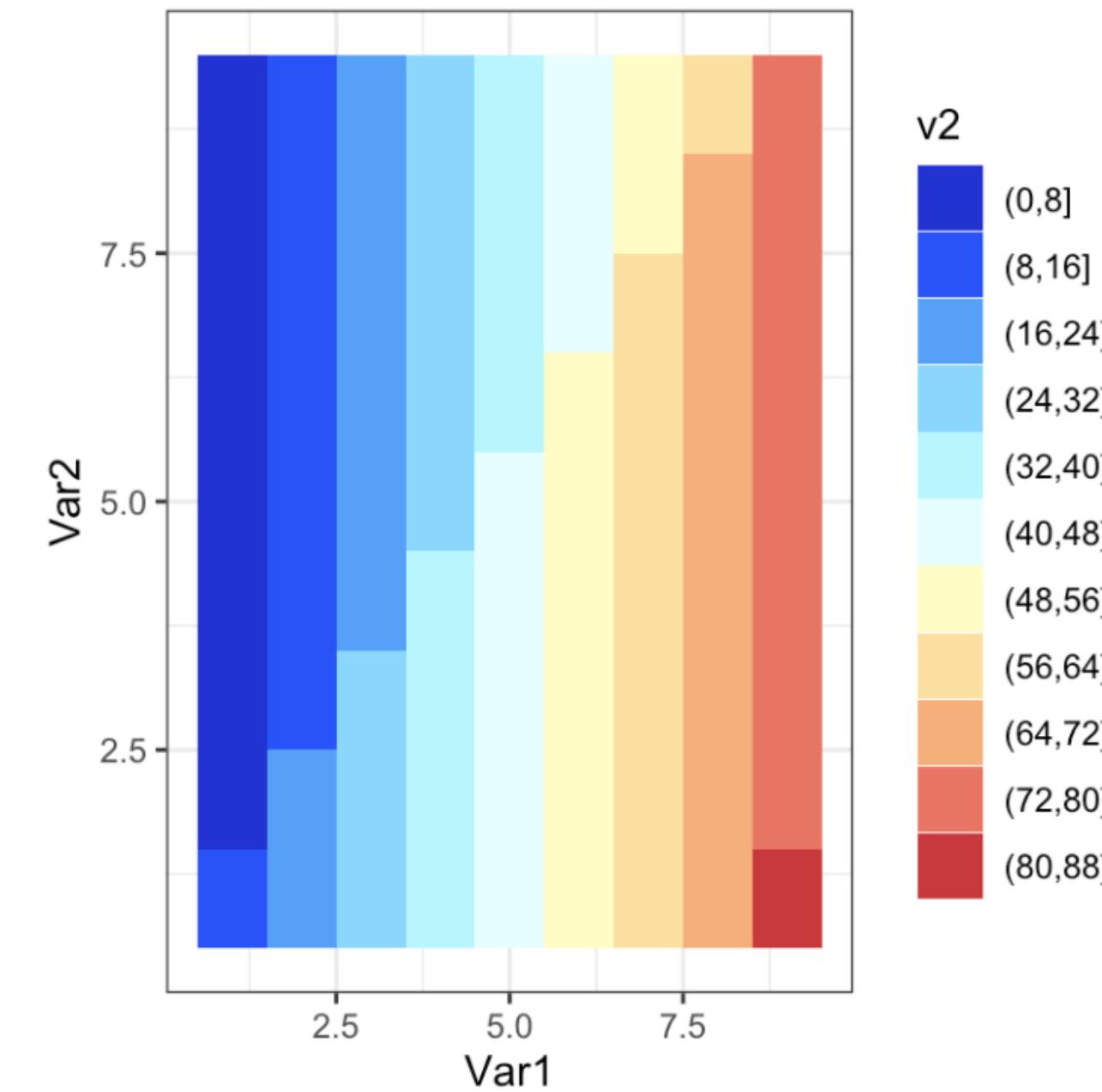
- Colorblindness para R
- Coblis [www.color-blindness.com](http://www.color-blindness.com)
- Color Brewer 2.0



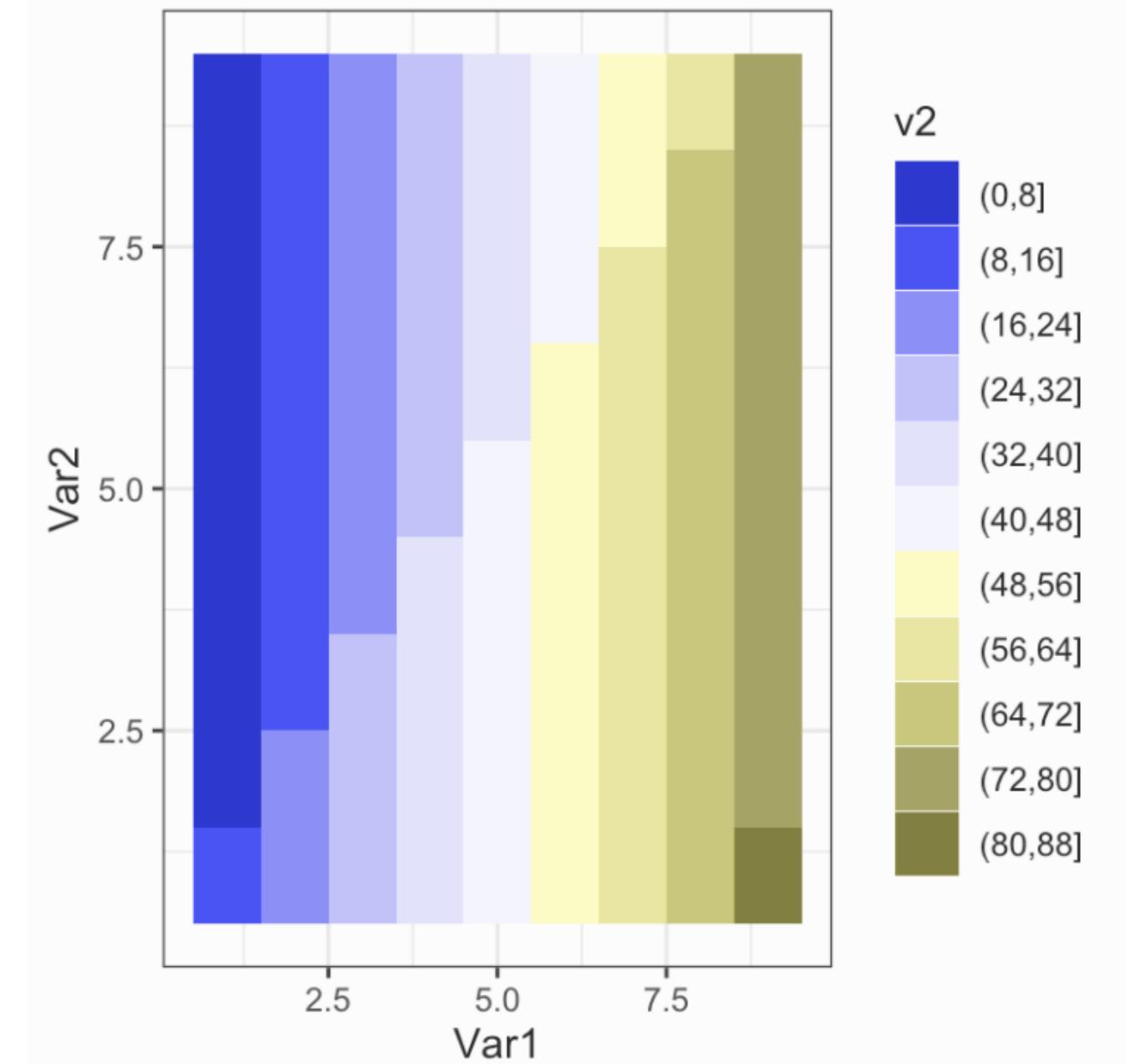
```
library(colorBlindness)
mat <- matrix(1:81, nrow = 9, ncol = 9)

library(ggplot2)
library(reshape2)
mat1 <- melt(t(mat[9:1, ]))
len <- length(Blue2DarkRed12Steps)-1
mat1$v2 <- cut(mat1$value,
                 breaks = seq(0,ceiling(81/len)*len,
                               length.out = len+1))
ht <- ggplot(mat1) +
  geom_tile(aes(x=Var1, y=Var2, fill=v2)) +
  scale_fill_manual(values=Blue2DarkRed12Steps) +
  theme_bw()
# check the plot by CVD simulator
cvdPlot(ht)
```

normal vision



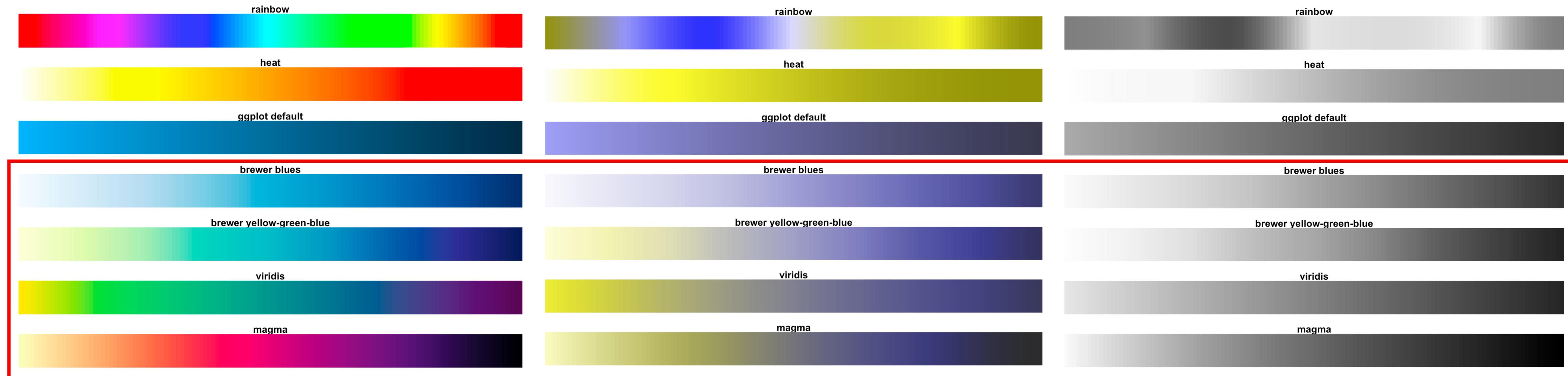
deuteranopia (6%)



# Escalas perceptualmente correctas

Viridis. Perceptualmente correctas; corregidas para color deficiency y B/N

<https://cran.r-project.org/web/packages/viridis/vignettes/intro-to-viridis.html>



# Buscar “Perceptually correct”

## Color Brewer

### Viridis color scales (R, plotly, etc.)

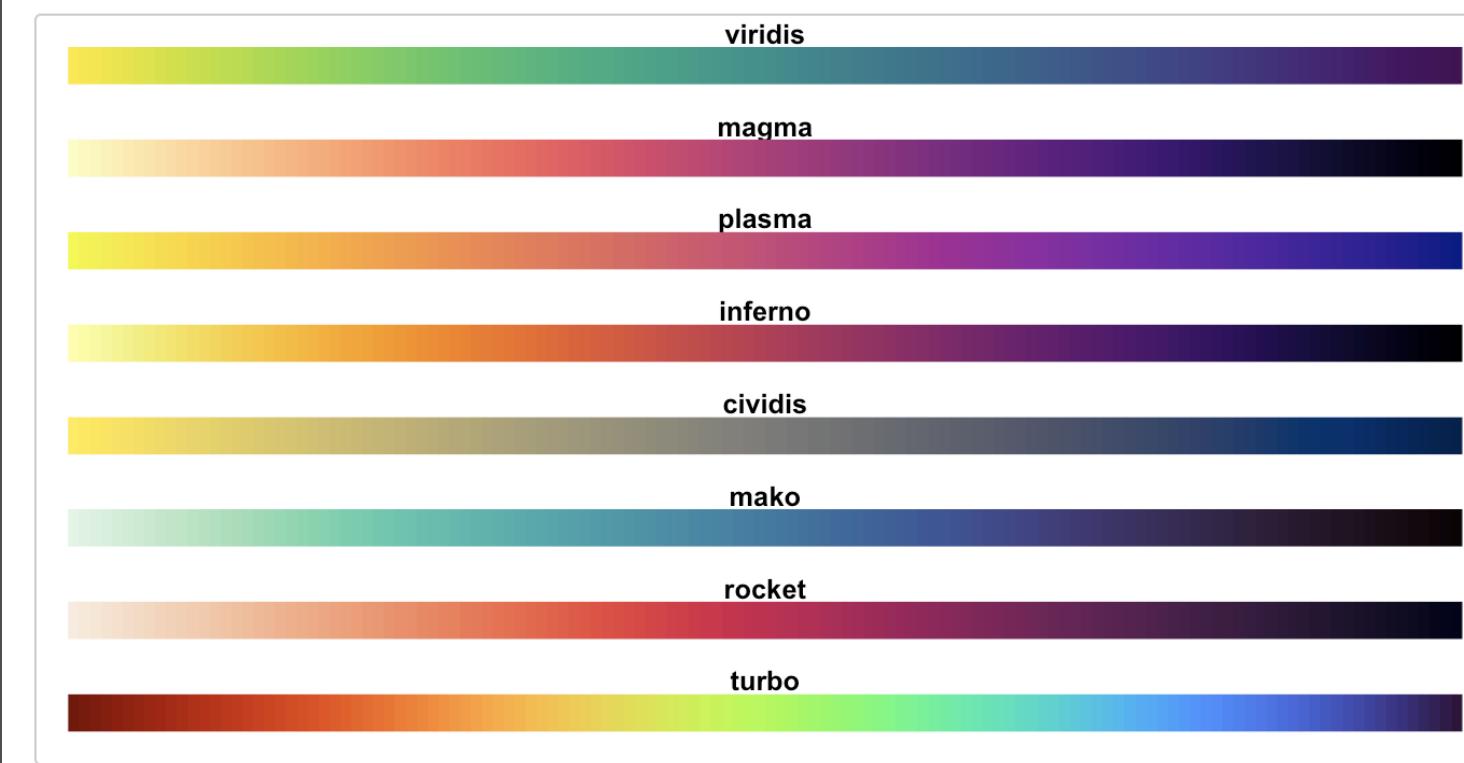
The package contains eight color scales: "viridis", the primary choice, and five alternatives with similar properties - "magma", "plasma", "inferno", "cividis", "mako", and "rocket" -, and a rainbow color map - "turbo".

The color maps viridis, magma, inferno, and plasma were created by Stéfan van der Walt ([@stefanv] (<https://github.com/stefanv>)) and Nathaniel Smith ([@njsmith] (<https://github.com/njsmith>)). If you want to know more about the science behind the creation of these color maps, you can watch this [presentation of viridis](#) by their authors at [SciPy 2015](#).

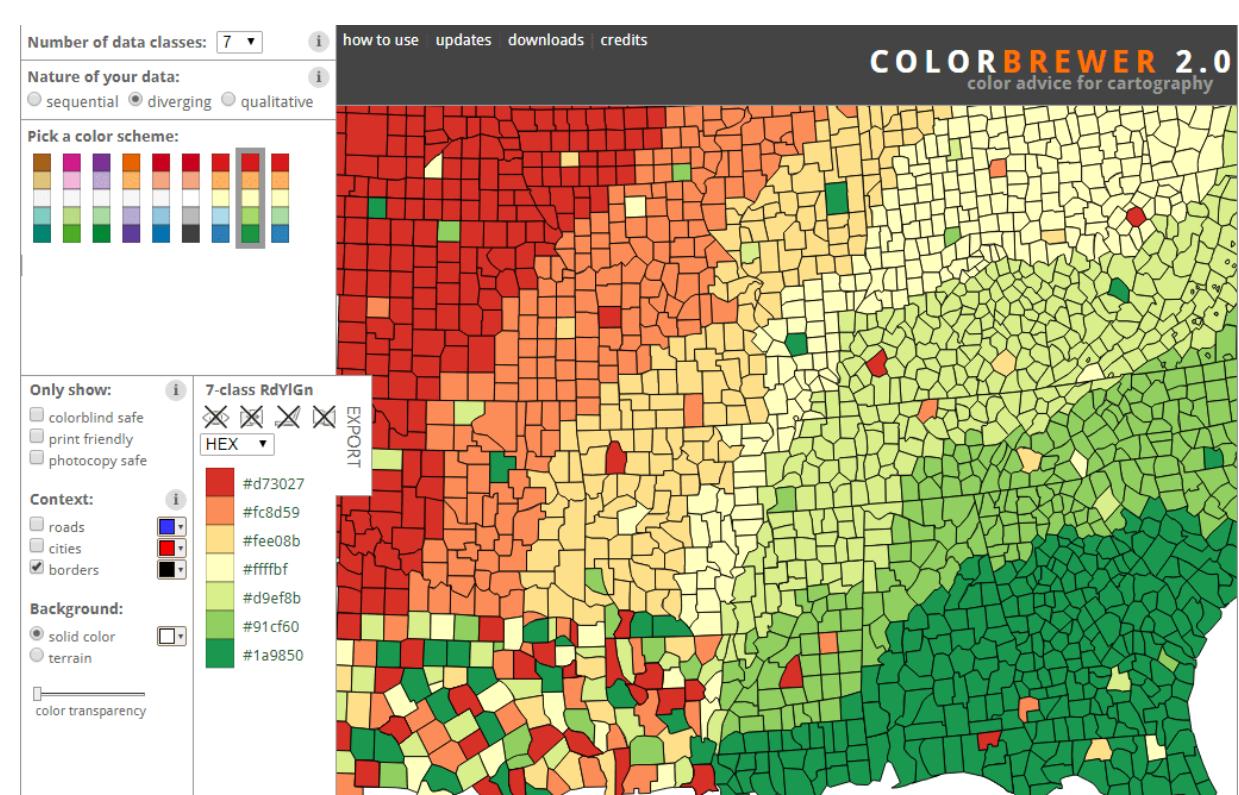
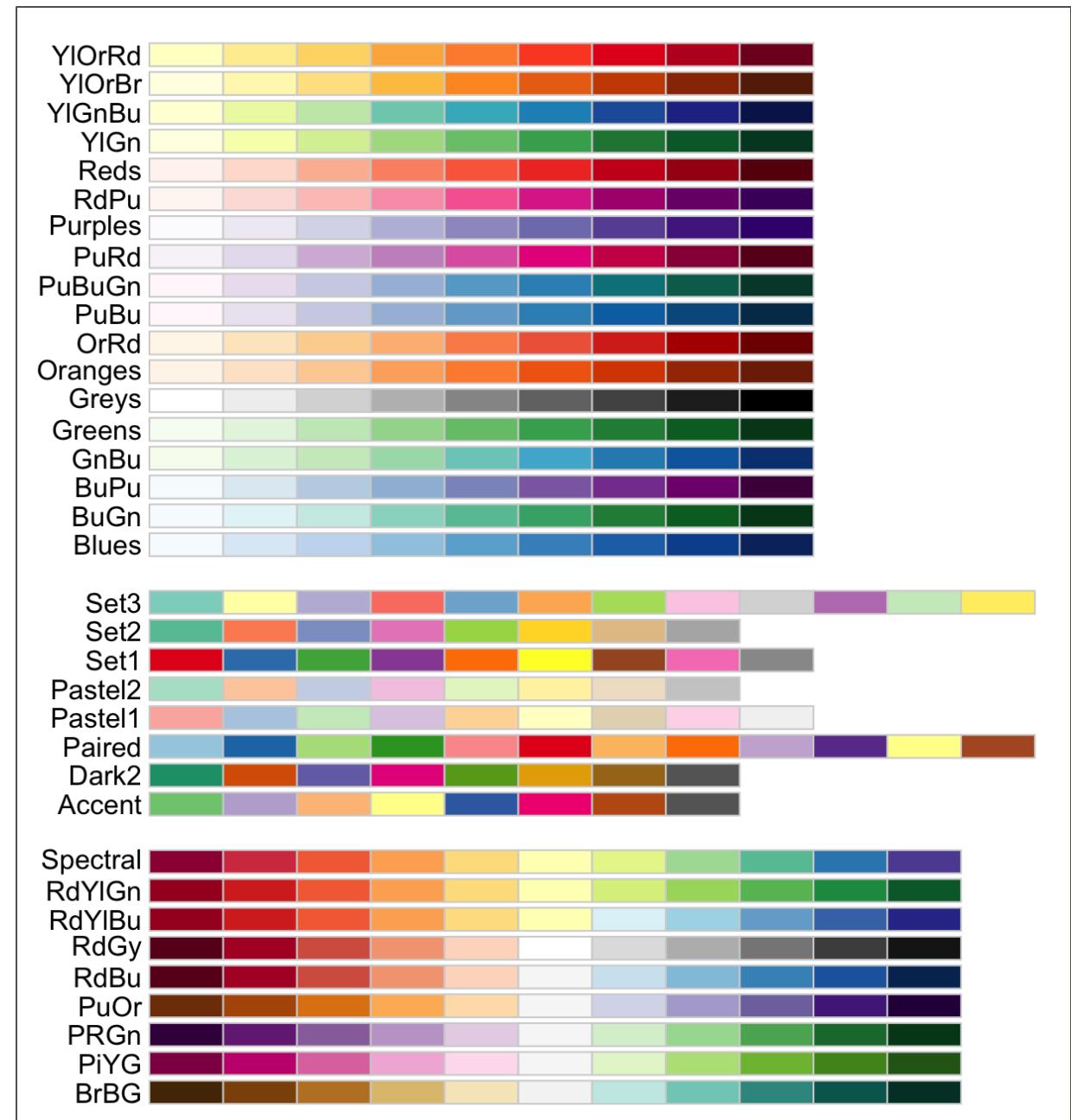
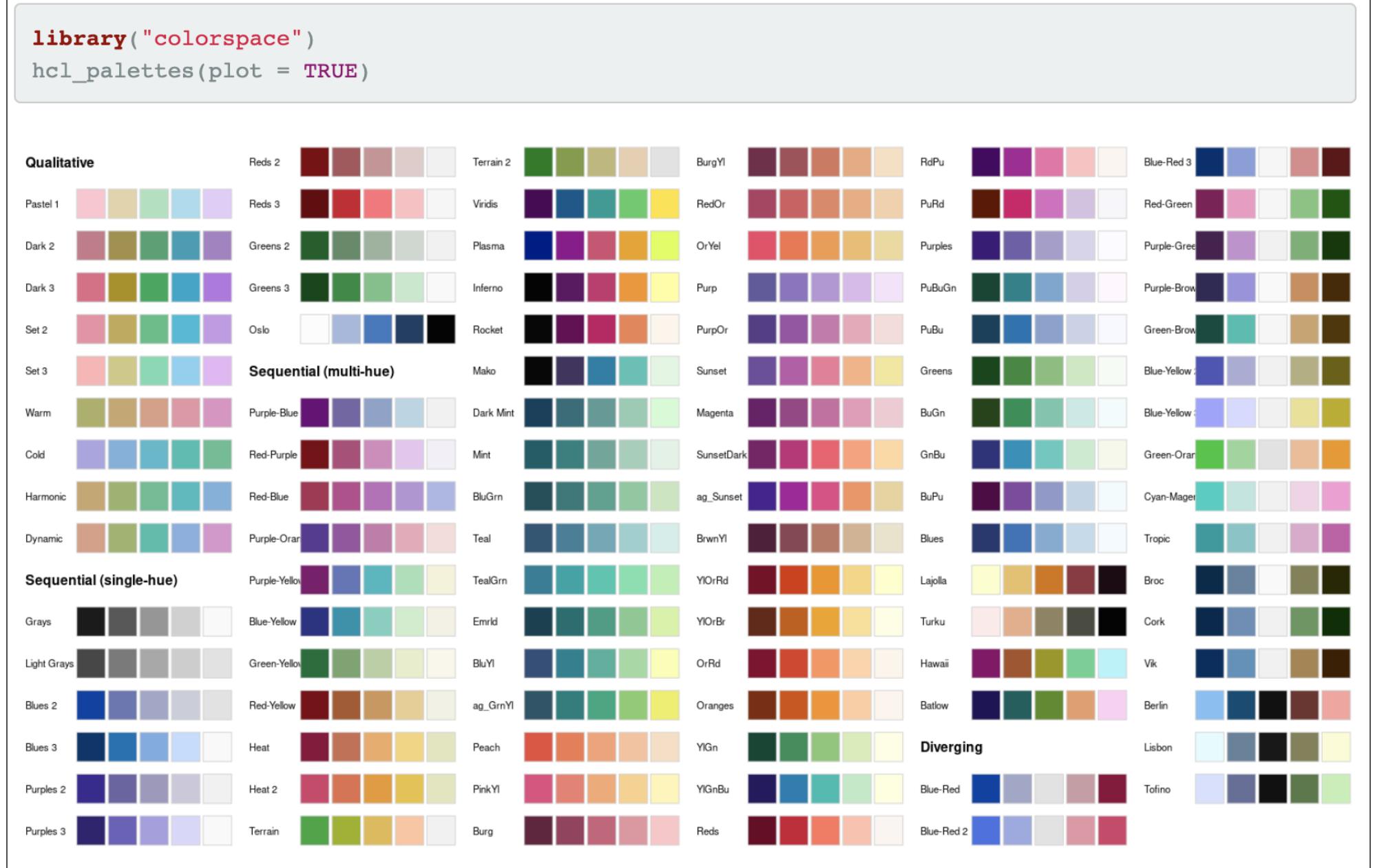
The color map cividis is a corrected version of 'viridis', developed by Jamie R. Nuñez, Christopher R. Anderton, and Ryan S. Renslow, and originally ported to R by Marco Sciaiani ([@msciain] (<https://github.com/marcoscii>))). More info about cividis can be found in [this paper](#).

The color maps mako and rocket were originally created for the Seaborn statistical data visualization package for Python. More info about mako and rocket can be found on the [Seaborn website](#).

The color map turbo was developed by Anton Mikhailov to address the shortcomings of the Jet rainbow color map such as false detail, banding and color blindness ambiguity. More info about turbo can be found [here](#).



### R- colorspace



# R cheatsheet

- No se trata solo de estética
- Usar esquemas de color que funcionen sobre sistemas basados en percepción: HSV, HSL, CIEL
- Accesibilidad: tener en cuenta color-blindness
- Elegir paletas de color en función del tipo de datos (categórico, cuantitativo, ordinal // secuencial, divergente, cílico)

## R color cheatsheet

Finding a good color scheme for presenting data can be challenging. This color cheatsheet will help!

### R uses hexadecimal to represent colors

Hexadecimal is a base-16 number system used to describe color. Red, green, and blue are each represented by two characters (#rrggb). Each character has 16 possible symbols: 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F:

"00" can be interpreted as 0.0 and "FF" as 1.0  
i.e., red= #FF0000 , black=#000000, white = #FFFFFF

Two additional characters (with the same scale) can be added to the end to describe transparency (#rrggbaa)

### R has 657 built in color names Example:

To see a list of names:

`colors()`

These colors are displayed on P. 3.

peachpuff4

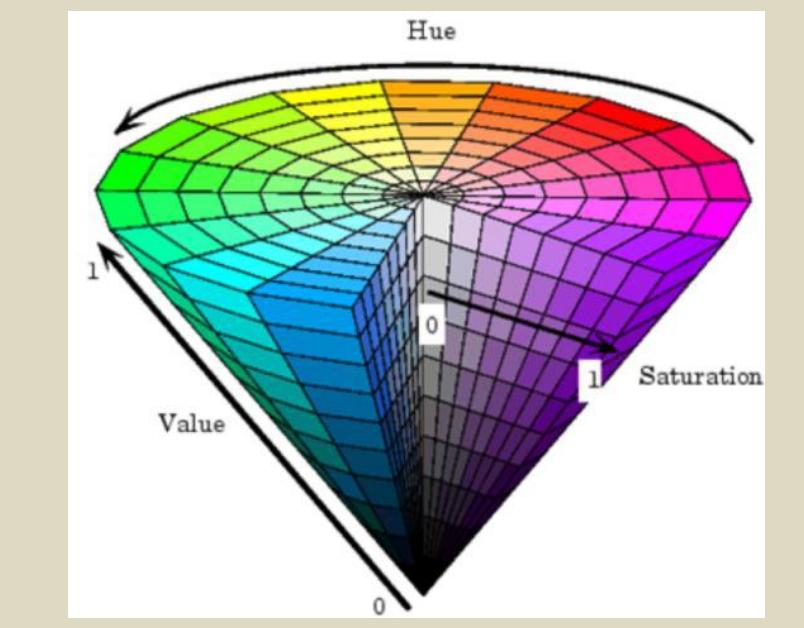
### R translates various color models to hex, e.g.:

- RGB (red, green, blue): The default intensity scale in R ranges from 0-1; but another commonly used scale is 0-255. This is obtained in R using maxColorValue=255. *alpha* is an optional argument for transparency, with the same intensity scale.  
`rgb(r, g, b, maxColorValue=255, alpha=255)`
- HSV (hue, saturation, value): values range from 0-1, with optional alpha argument  
`hsv(h, s, v, alpha)`
- HCL (hue, chroma, luminance): hue describes the color and ranges from 0-360; 0 = red, 120 = green, blue = 240, etc. Range of chroma and luminance depend on hue and each other  
`hcl(h, c, l, alpha)`

### A few notes on HSV/HLC

HSV is a better model for how humans perceive color. HCL can be thought of as a perceptually based version of the HSV model....blah blah blah...

Without delving into color theory: color schemes based on HSV/HLC models generally just look good.



R can translate colors to rgb (this is handy for matching colors in other programs)  
`col2rgb(c("#FF0000", "blue"))`

### R Color Palettes

This is for all of you who don't know anything about color theory, and don't care but want some nice colors on your map or figure....NOW!

TIP: When it comes to selecting a color palette, **DO NOT** try to handpick individual colors! You will waste a lot of time and the result will probably not be all that great. R has some good packages for color palettes. Here are some of the options

#### Packages: grDevices and colorRamps

grDevices comes with the base installation and colorRamps must be installed. Each palette's function has an argument for the number of colors and transparency (*alpha*):

`heat.colors(4, alpha=1)`

`> #FF0000FF "#FF8000FF" "#FFFF00FF" "#FFFF80FF"`

For the rainbow palette you can also select start/end color (red = 0, yellow = 1/6, green = 2/6, cyan = 3/6, blue = 4/6 and magenta = 5/6) and saturation (s) and value (v):  
`rainbow(n, s = 1, v = 1, start = 0, end = max(1, n - 1)/n, alpha = 1)`

`grDevices palettes cm.colors topo.colors terrain.colors heat.colors rainbow`  
see P. 4 for options

#### Package: RcolorBrewer

This function has an argument for the number of colors and the color palette (see P. 4 for options).

`brewer.pal(4, "Set3")`

`> "#8DD3C7" "#FFFFB3" "#BEBADA" "#FB8072"`

To view colorbrewer palettes in R: `display.brewer.all(5)`  
There is also a very nice interactive viewer:  
<http://colorbrewer2.org/>

### ## My Recommendation ##

#### Package: colorspace

These color palettes are based on HCL and HSV color models. The results can be very aesthetically pleasing. There are some default palettes:

`rainbow_hcl(4)`

`"#E495A5" "#ABB065" "#39BEB1" "#ACA4E2"`

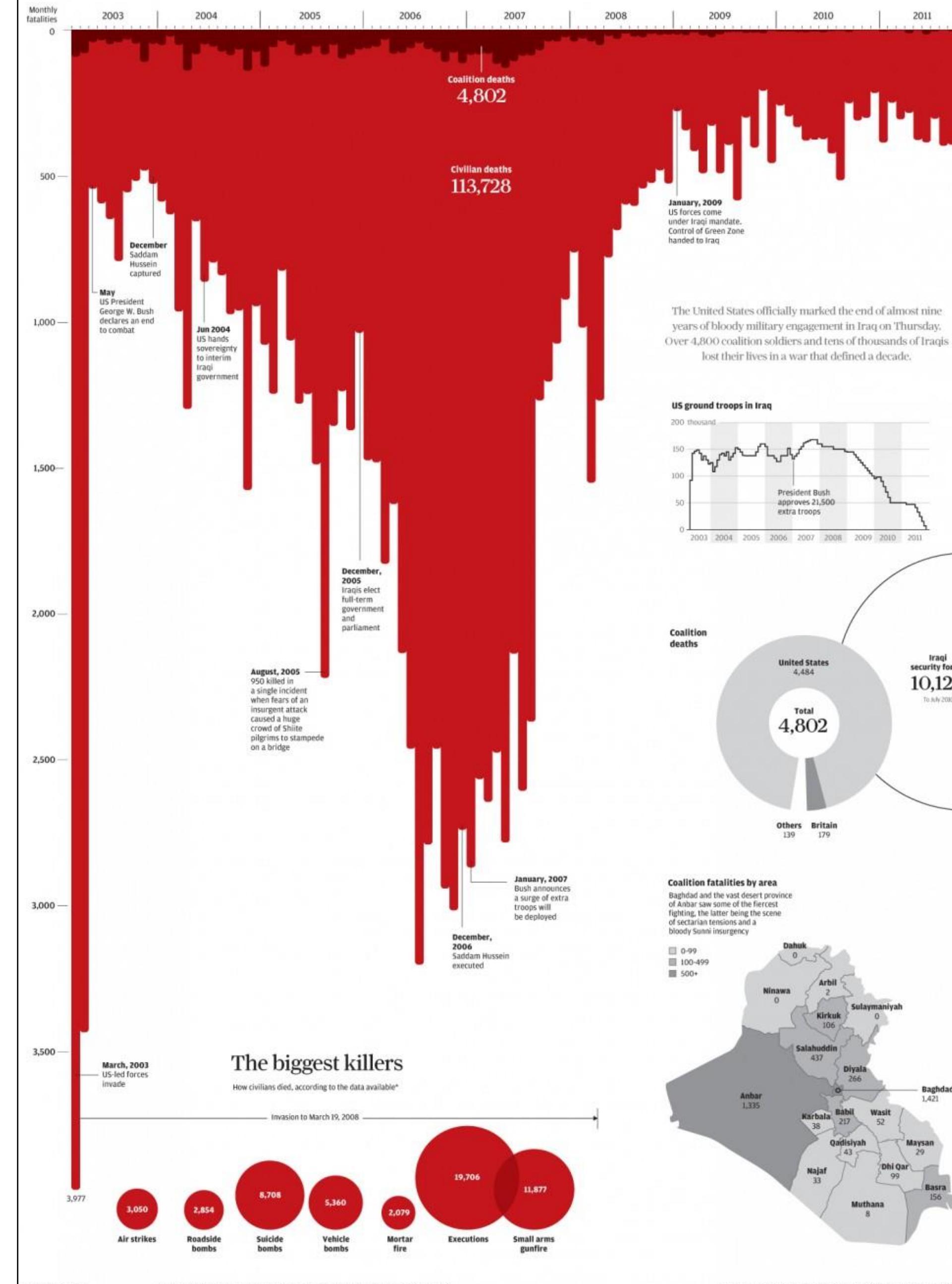
`colorspace default palettes diverge_hcl diverge_hsl terrain_hcl sequential_hcl rainbow_hcl`

However, all palettes are fully customizable:

`diverge_hcl(7, h = c(246, 40), c = 96, l = c(65, 90))`

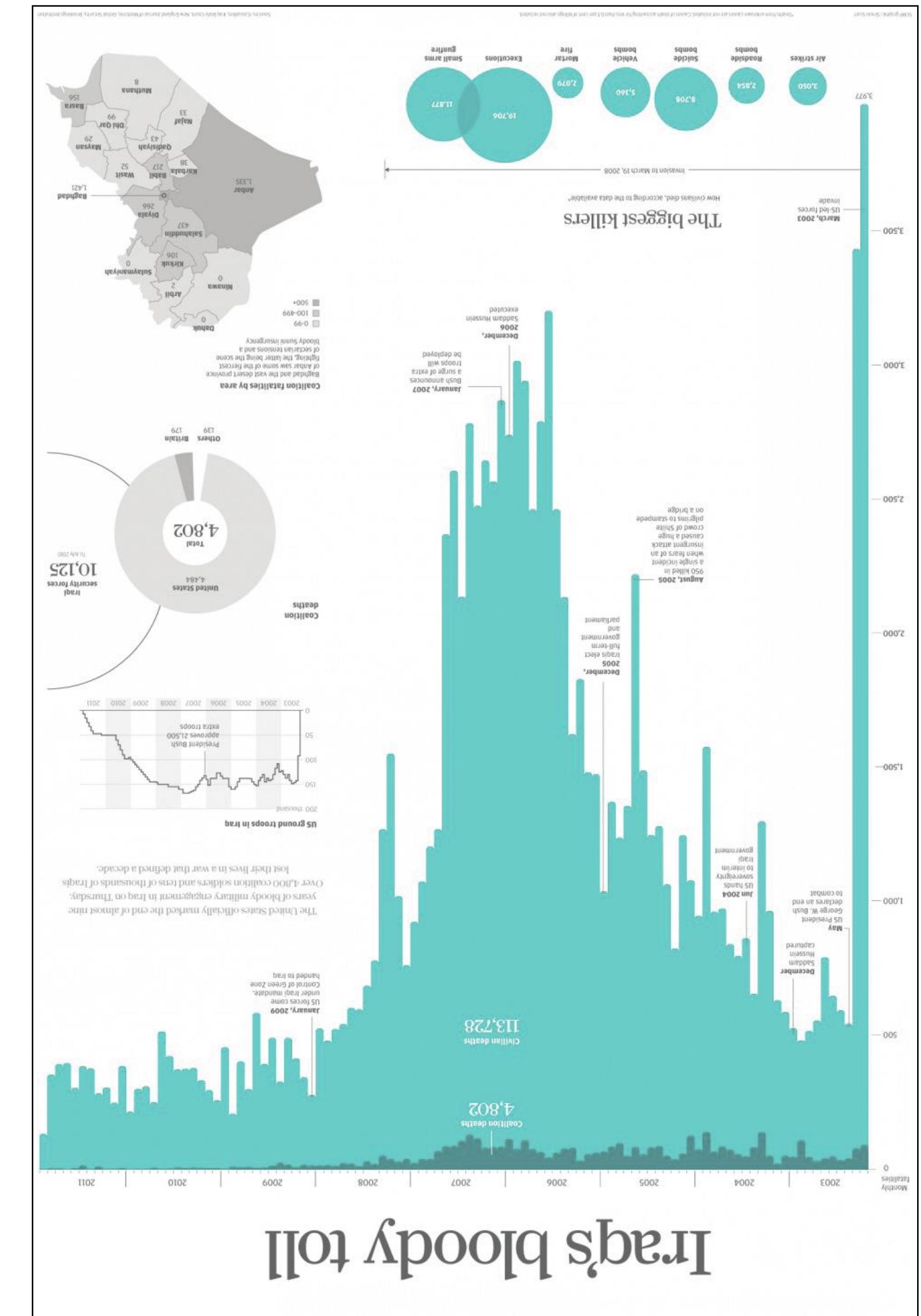
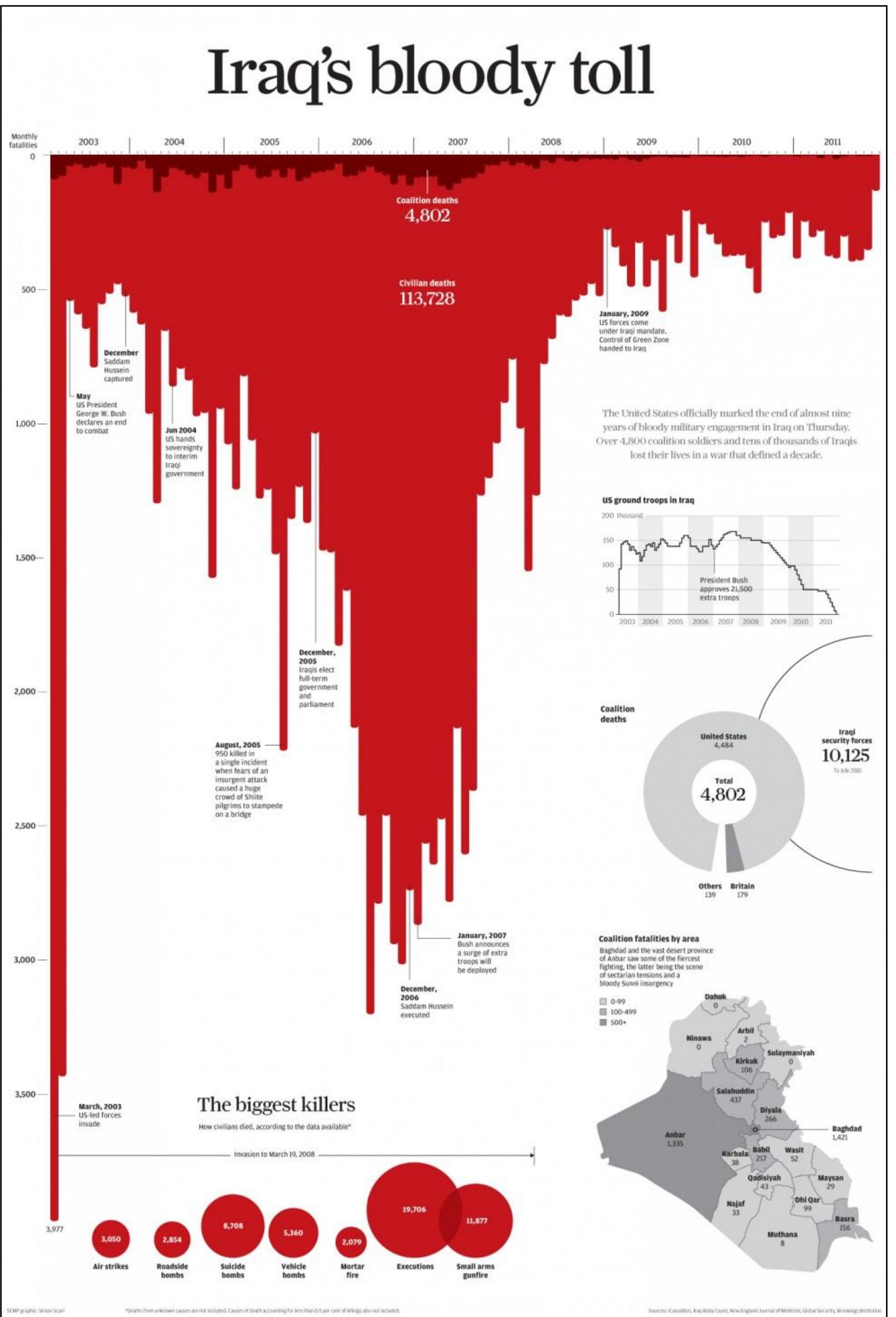
Choosing the values would be daunting. But there are some recommended palettes in the colorspace documentation. There is also an interactive tool that can be used to obtain a customized palette. To start the tool:  
`pal <- choose_palette()`

# Iraq's bloody toll

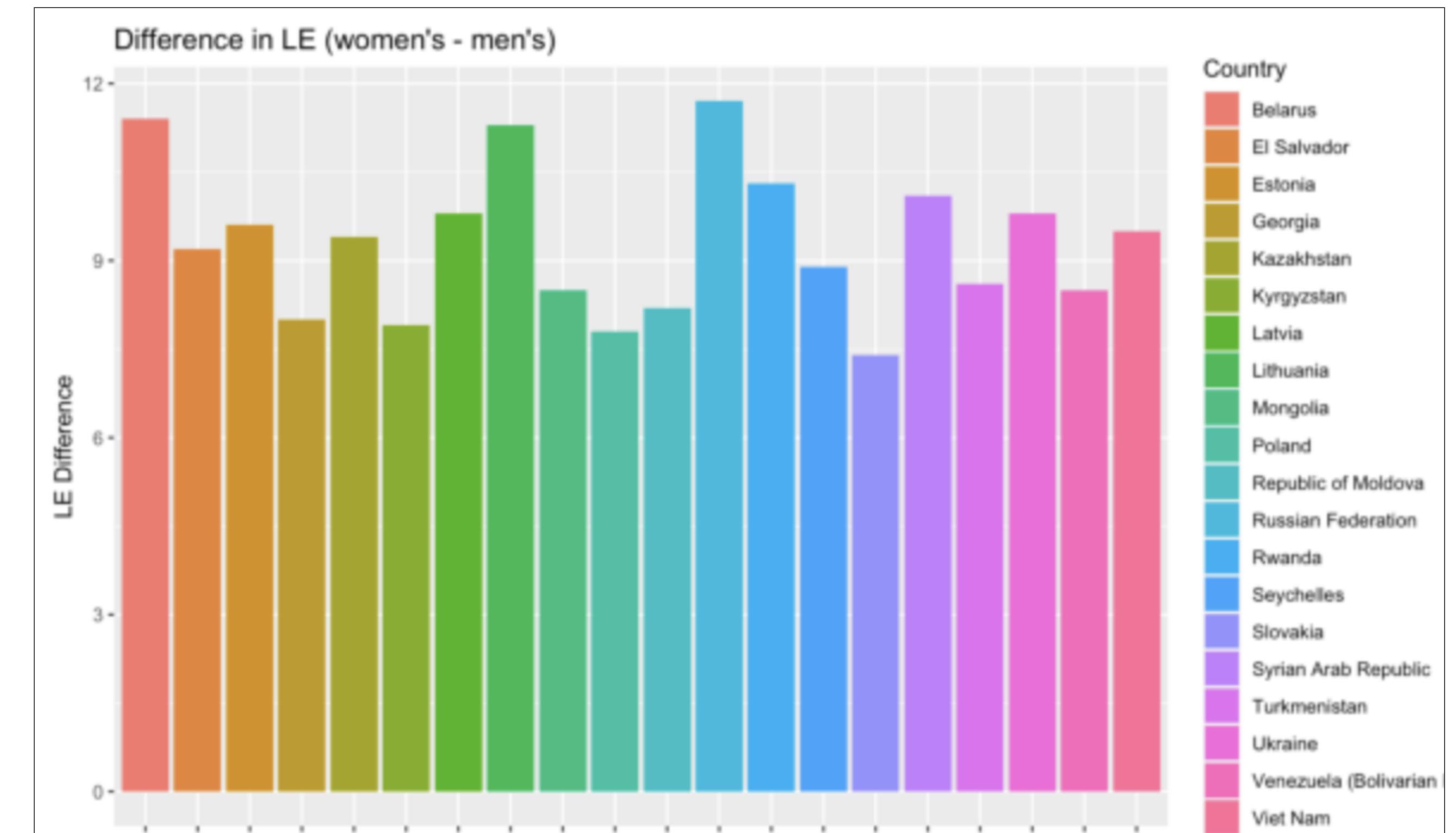
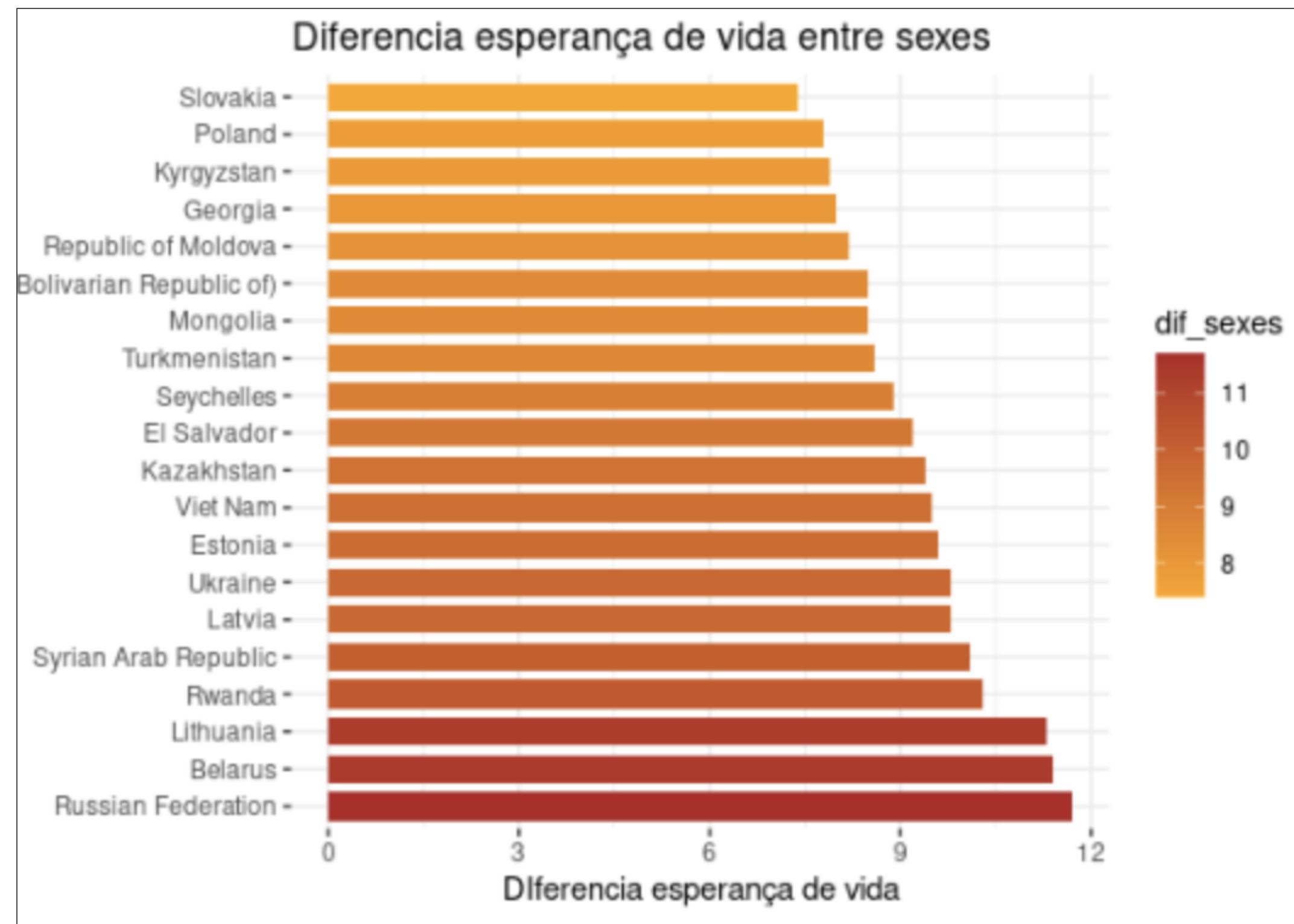


## Semántica del color

# Semántica del color

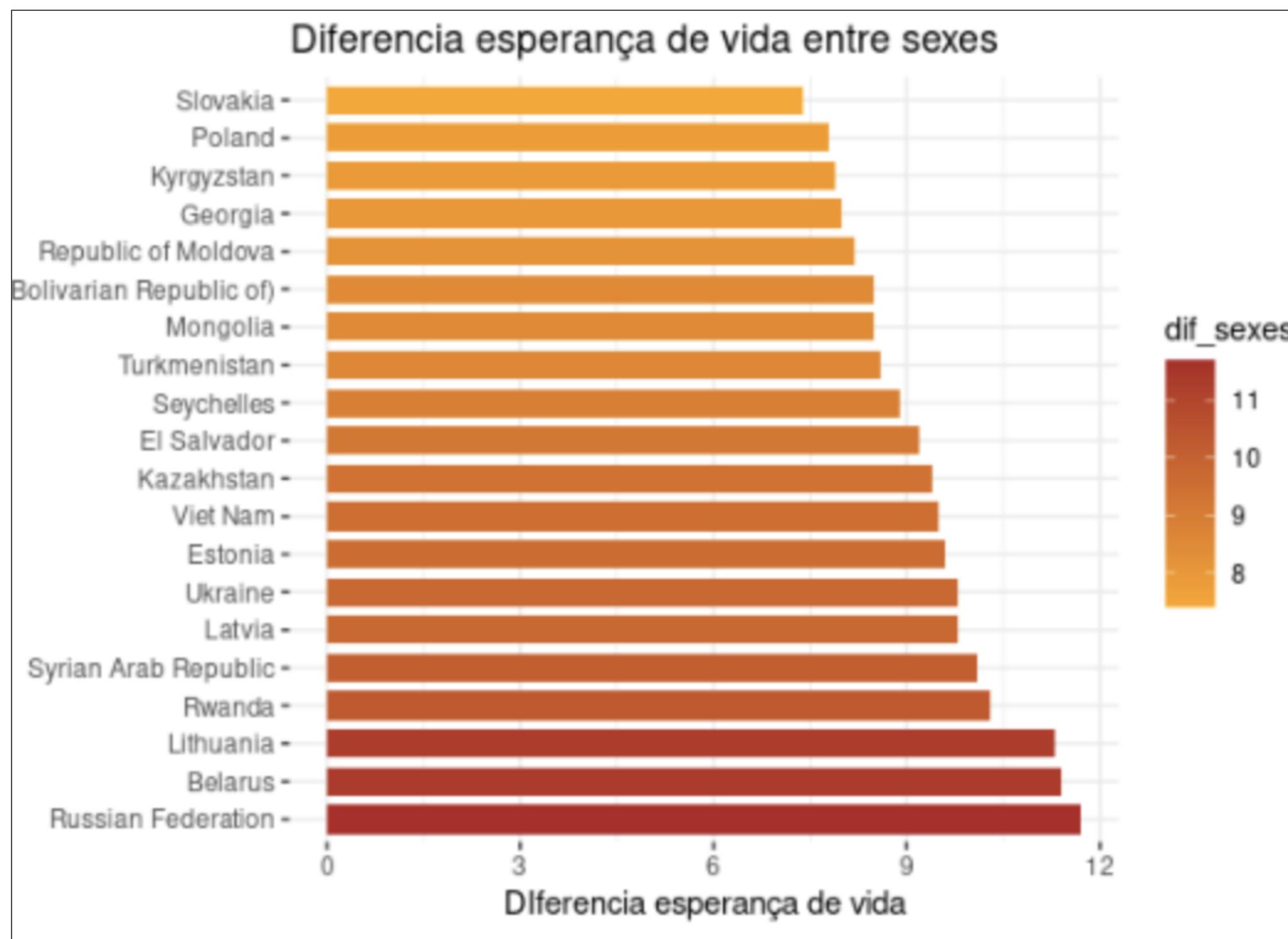


- Gráficas de diferencia en Esperanza de Vida al Nacer – Top 20
- ¿Uso del color correcto?
- ¿Qué fallos tienen?



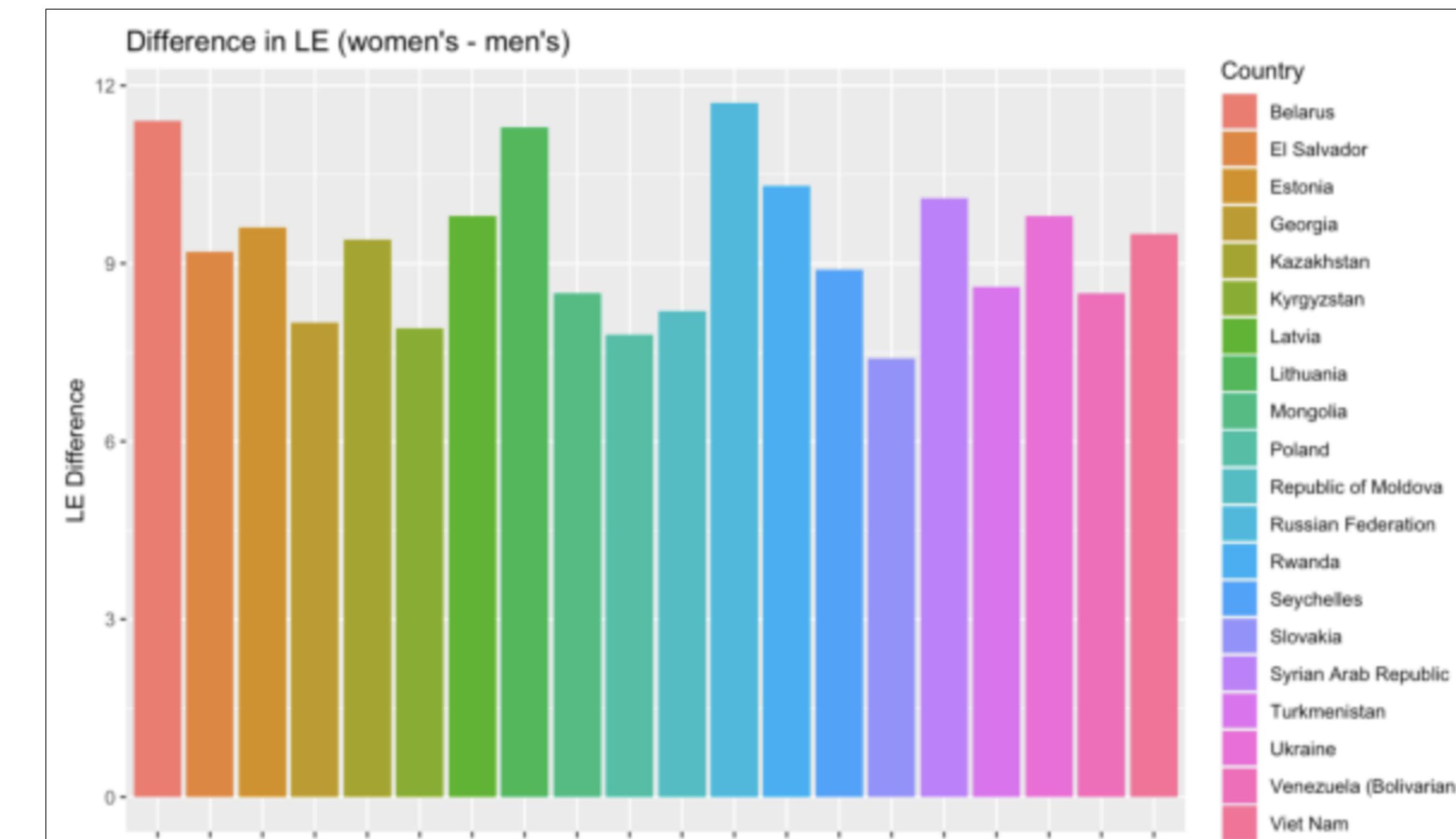
## Do's ...

- Escala bicromática continua
- Variación en tono y luminosidad
- Escala **continua** usada para **attr. cuantitativo continuo**
- Doble redundancia: Ranking ordenado por tamaño de barras, color



## ... and dont's

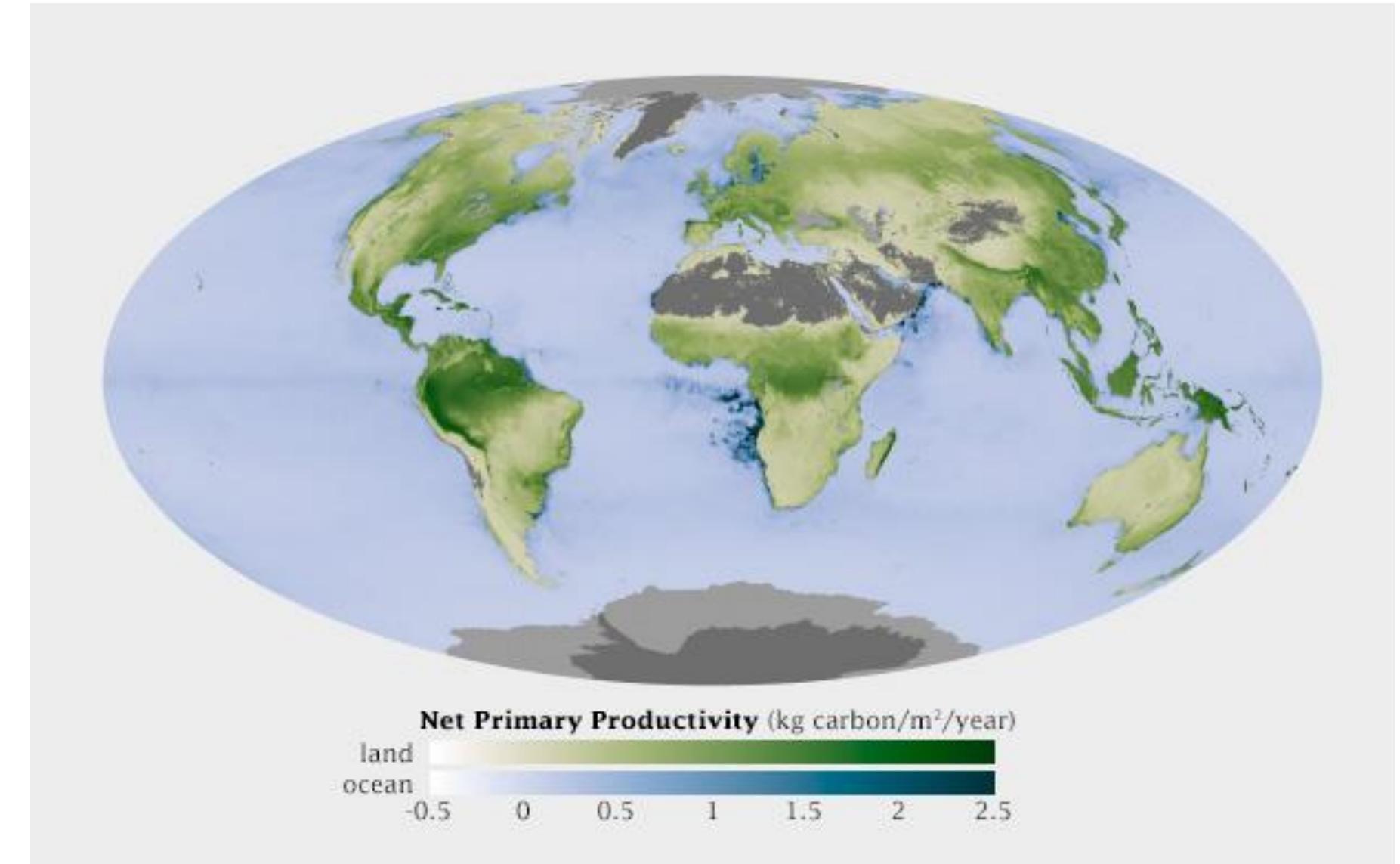
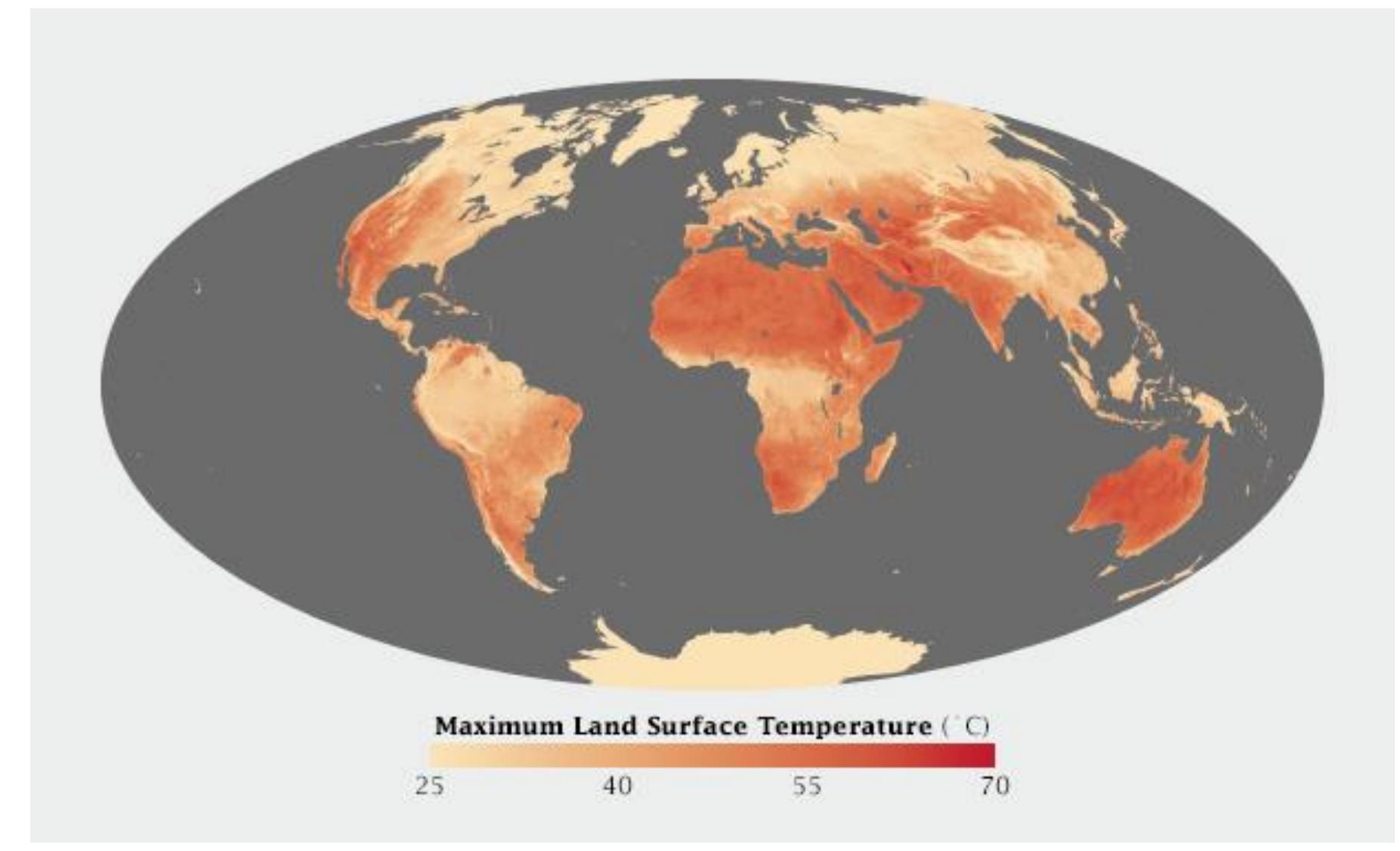
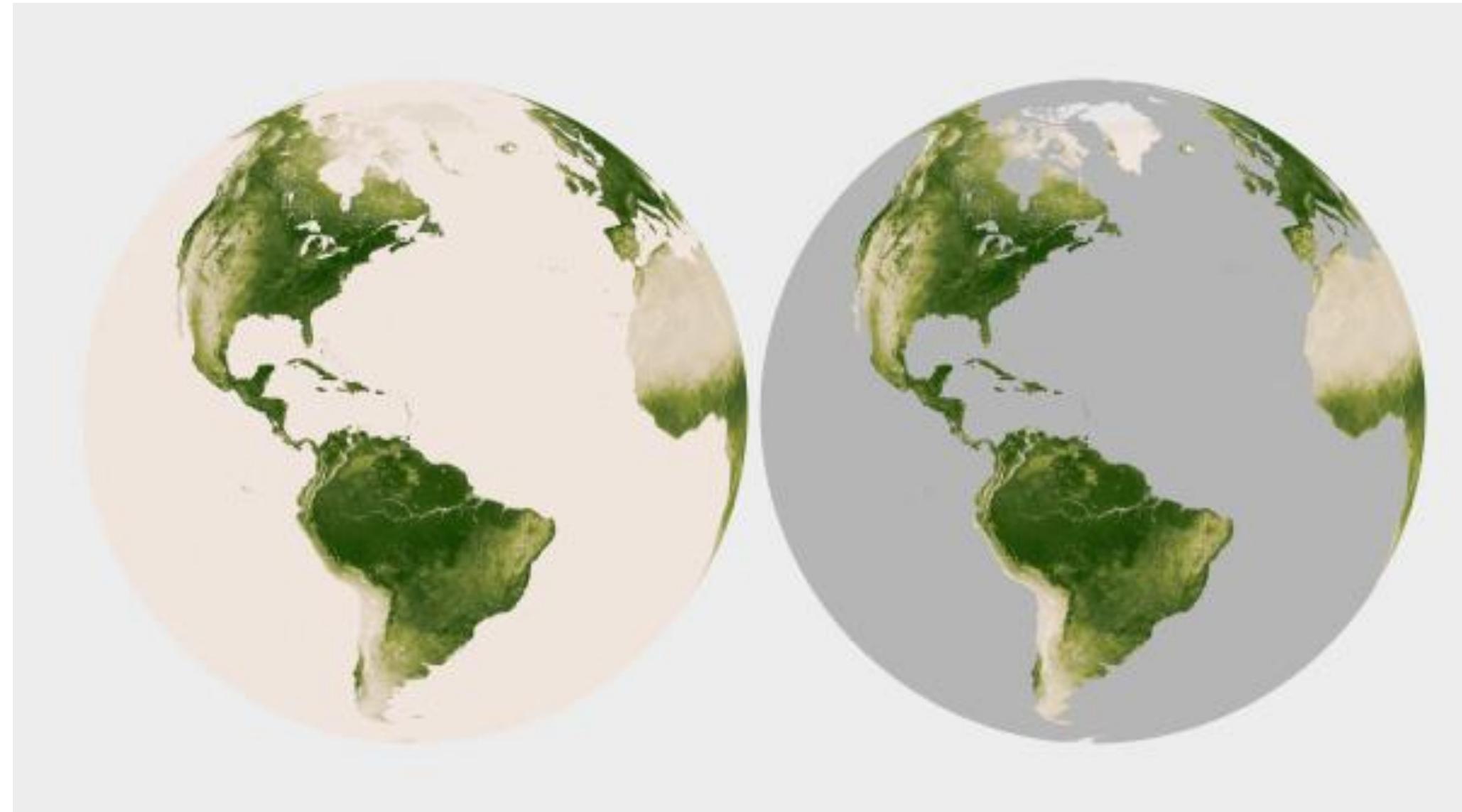
- Escala arcoíris, aunque con luminancia corregida
- Escala **continua** usada como **categórica**
- + de 12 categorías
- Ranking no ordenado
- Etiquetas del barchart fuera de la gráfica



# Buenas prácticas

Robert Simmon, 2013

- Asignar color a significado (paletas cálidas para altas temperaturas; divergente azul-rojo para temp negativa a positiva, verde para datos de vegetación, etc)
- Usar la escala correcta para cada tipo de atributo:
  - Si es categórico o cuantitativo/ordinal y
  - si es divergente, secuencial, o cíclico
- Elegir paletas con contraste en luminancia para resaltar detalles.
- Tener en cuenta color-blindness y usos (imprimir, colores web, etc)
- No data, no color



# Bibliografia

## Color:

- *Subtleties of color:* <https://earthobservatory.nasa.gov/blogs/elegantfigures/2013/08/05/subtleties-of-color-part-1-of-6/>
- *Tableau color palettes:* <https://www.tableau.com/about/blog/2016/7/colors-upgrade-tableau-10-56782>
- *Bi-variate choropleth maps:* [www.joshuastevens.net/cartography/make-a-bivariate-choropleth-map/](http://www.joshuastevens.net/cartography/make-a-bivariate-choropleth-map/)
- *R colorspace package:* <https://cran.r-project.org/web/packages/colorspace/vignettes/colorspace.html>

## Inspiración

<http://www.thefunctionalart.com/>

<https://eagereyes.org/>

<http://flowingdata.com/>

<http://fivethirtyeight.com/>

<http://truth-and-beauty.net/>



**Barcelona  
Supercomputing  
Center**  
*Centro Nacional de Supercomputación*



## 8.2 Honestidad y Precisión visual

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# Ejes

 National Review   
@NRO

The only **#climatechange** chart you need to see.  
[natl.re/wPKpro](http://natl.re/wPKpro)

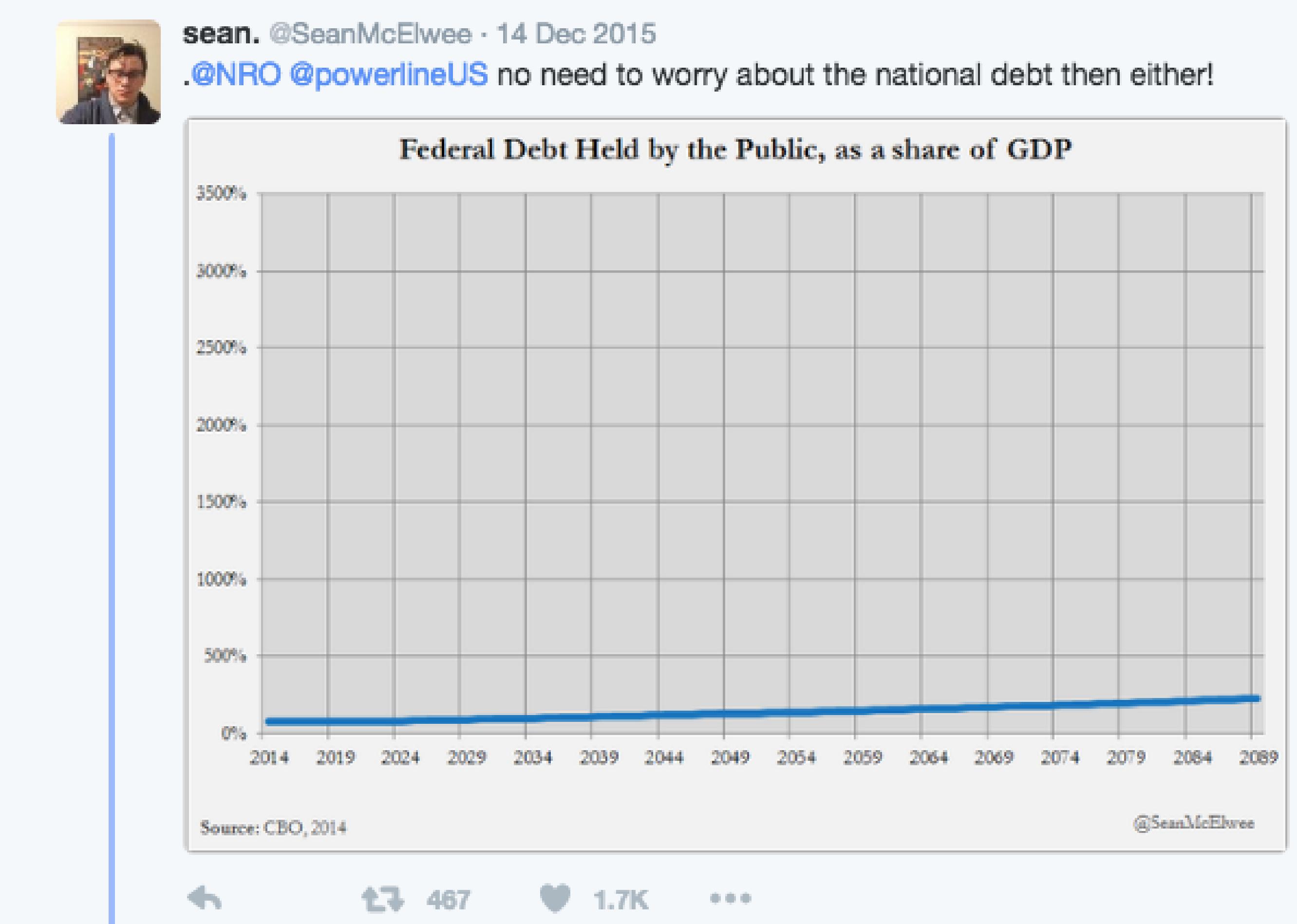
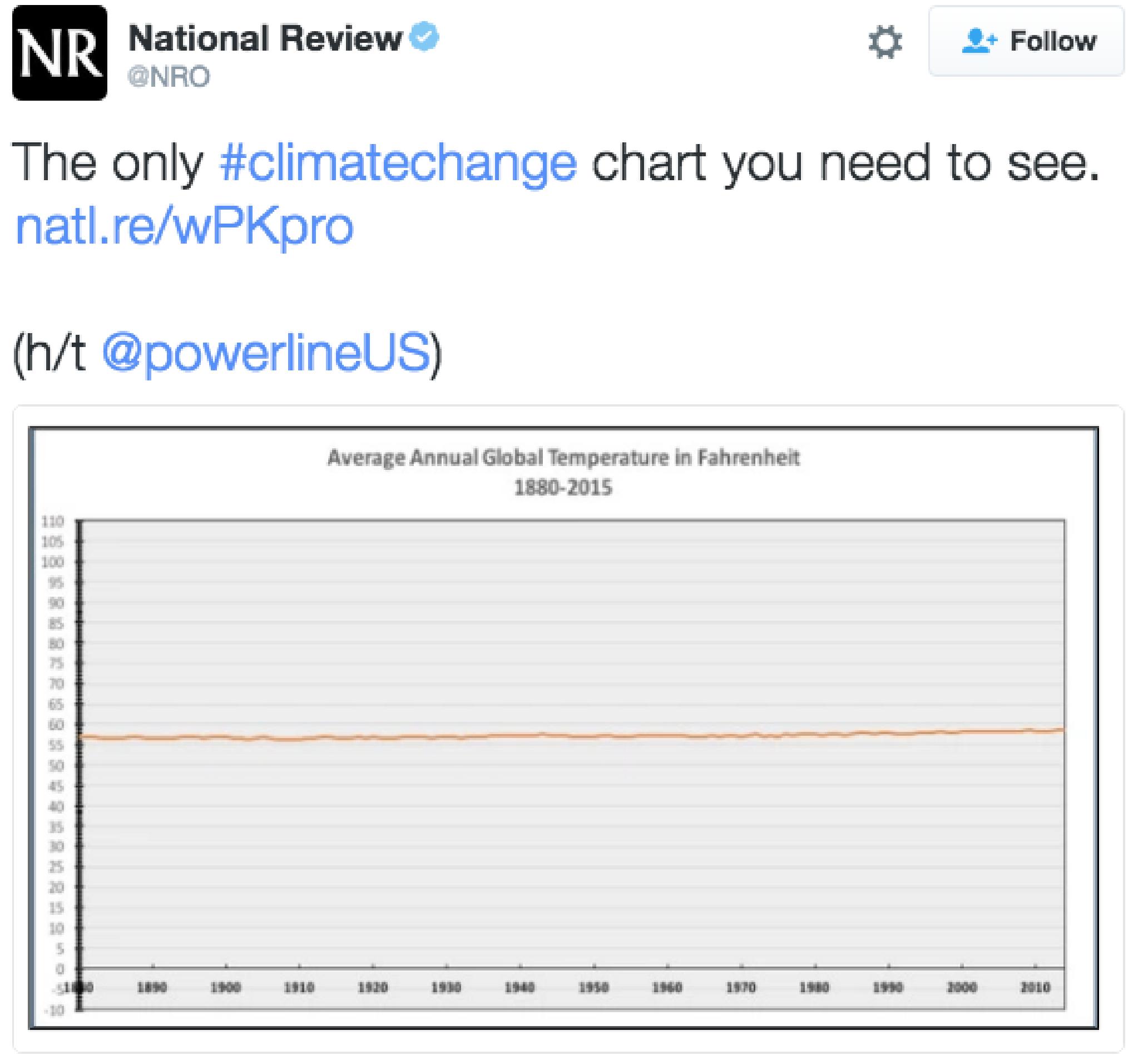
(h/t [@powerlineUS](#))

Average Annual Global Temperature in Fahrenheit  
1880-2015



Year	Temperature (F)
1880	58
1900	58
1920	58
1940	58
1960	58
1980	58
2000	59
2015	60

# Ejes



# Ejes



National Review

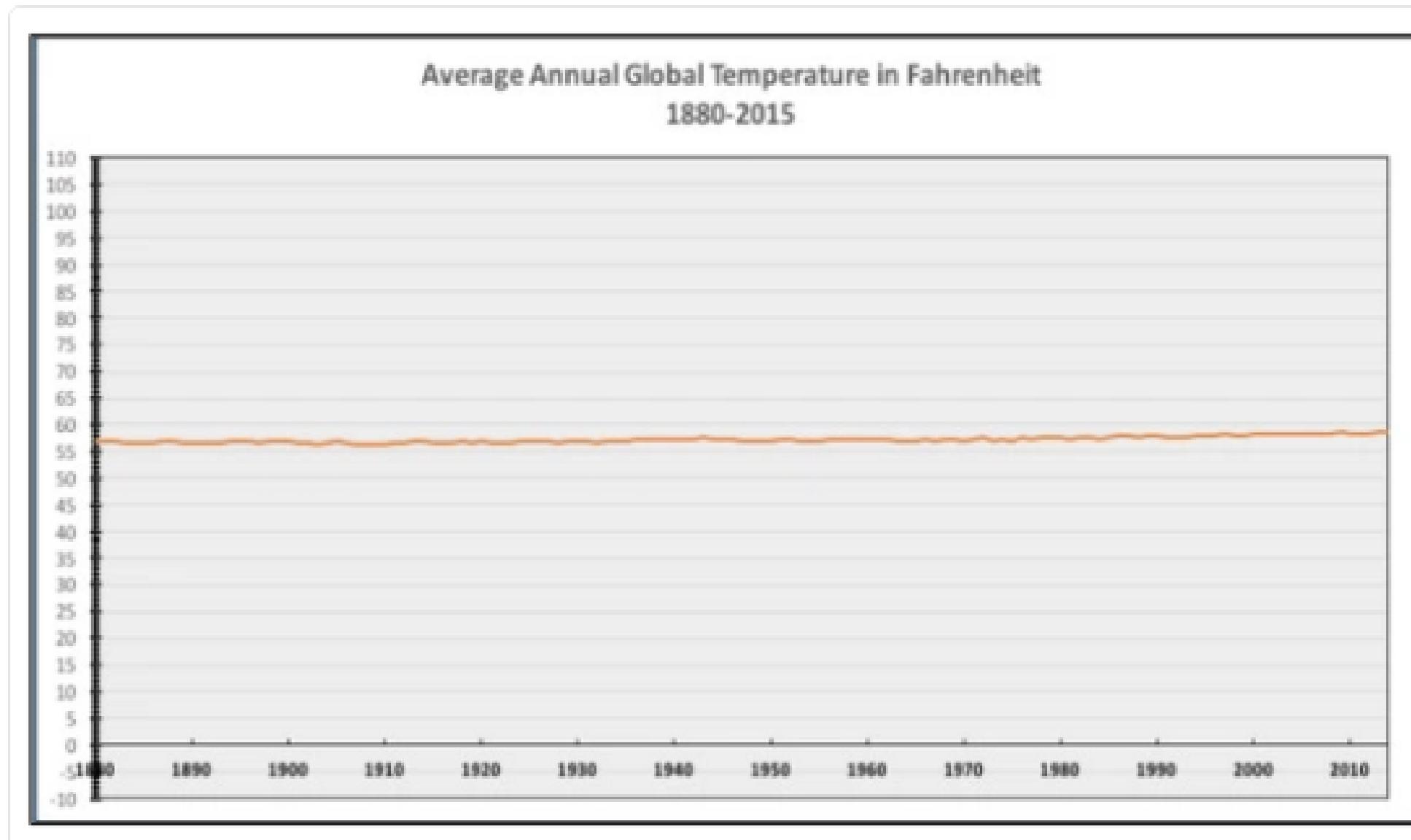
@NRO



Follow

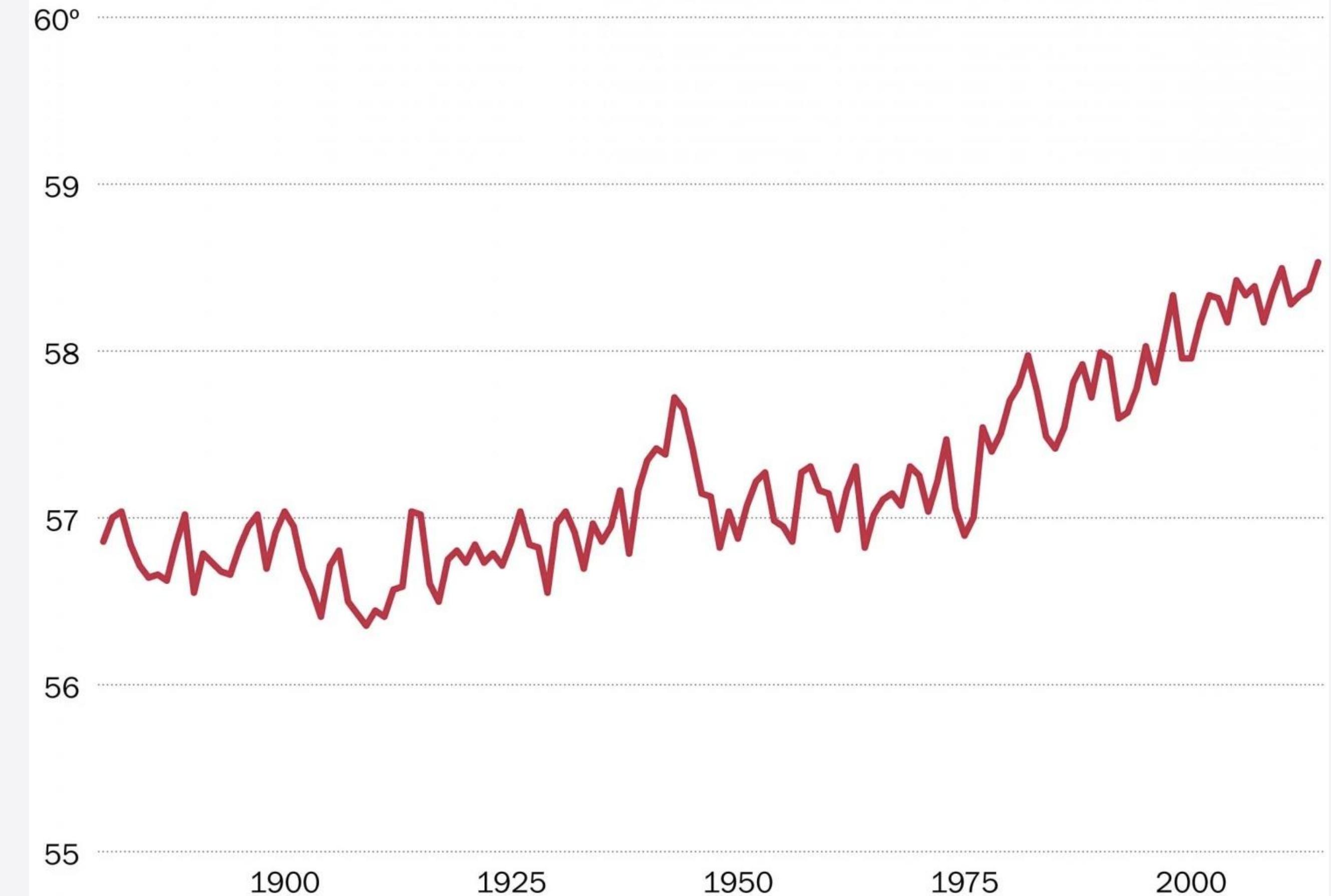
The only #climatechange chart you need to see.  
[natl.re/wPKpro](http://natl.re/wPKpro)

(h/t [@powerlineUS](#))

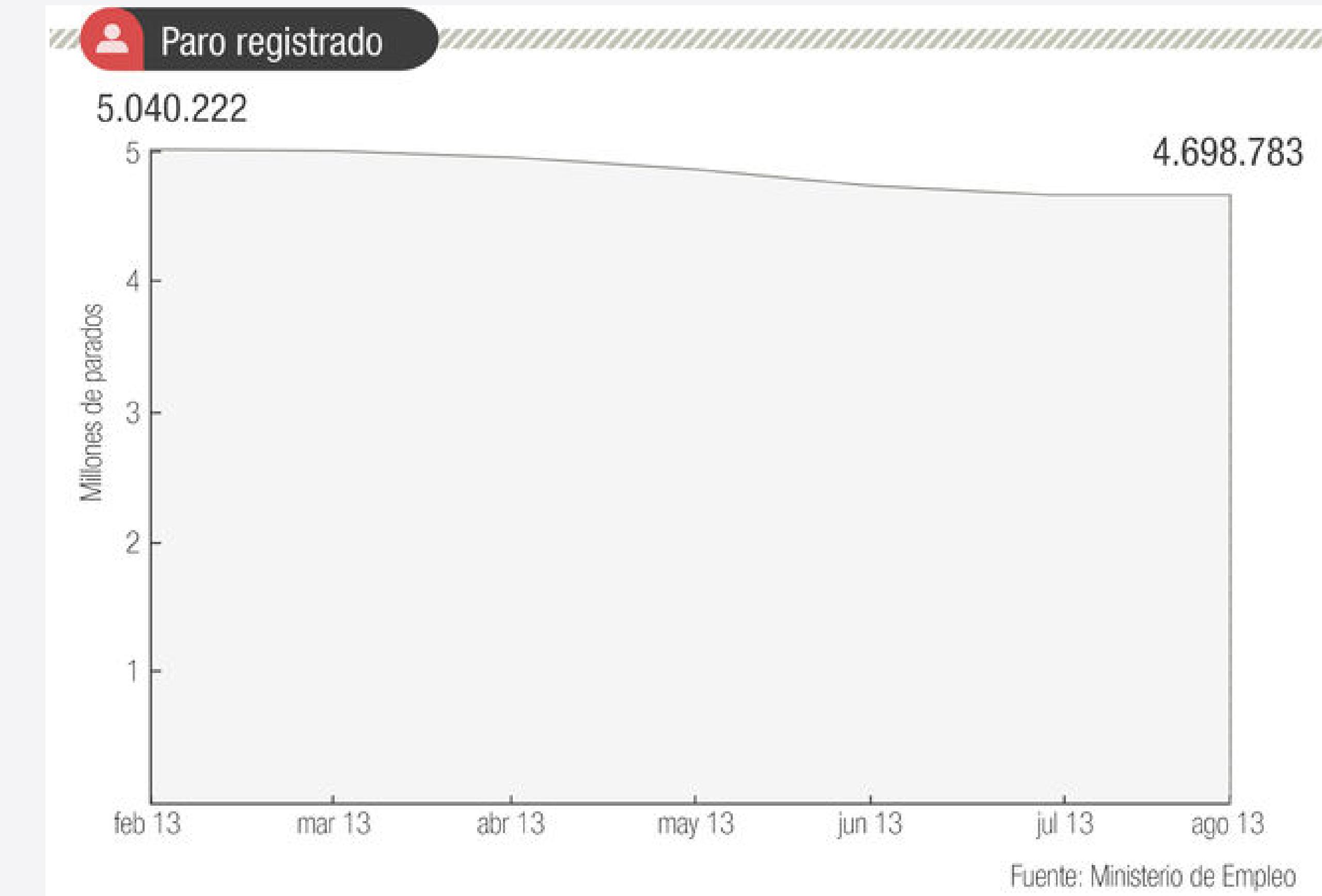


## Average global temperature by year

Data from NASA/GISS.

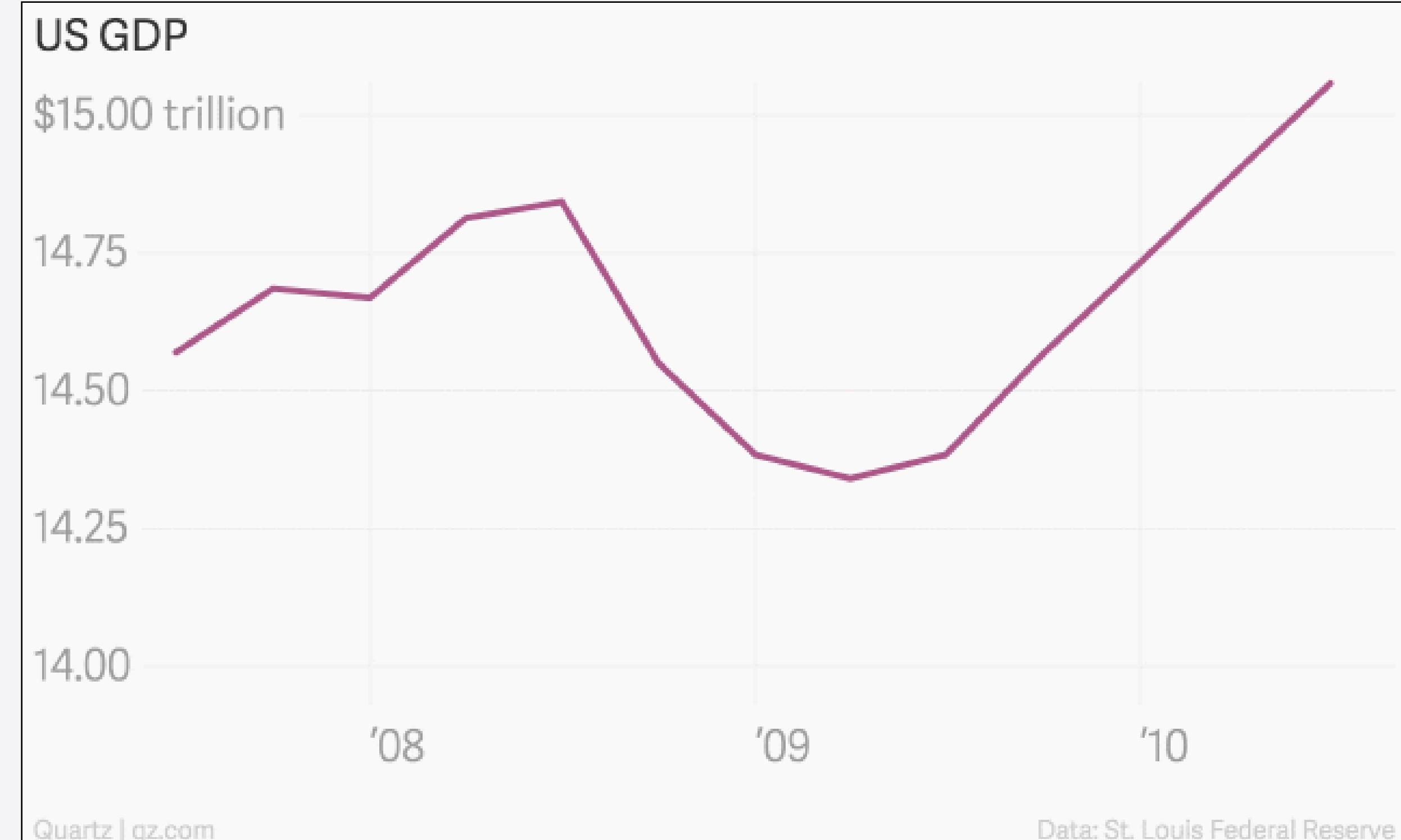
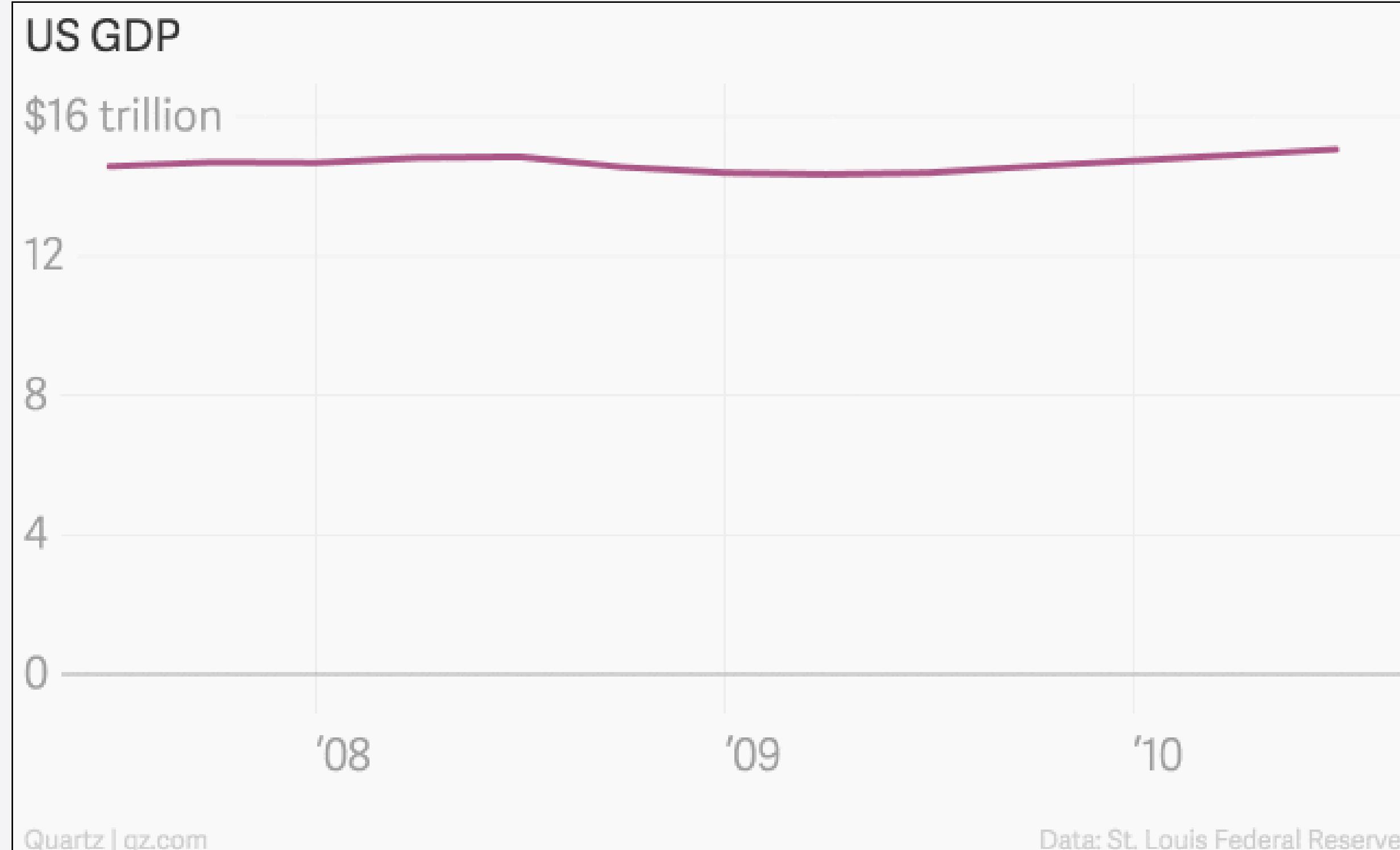


# Ejes



Mostrar eje completo para no magnificar el descenso

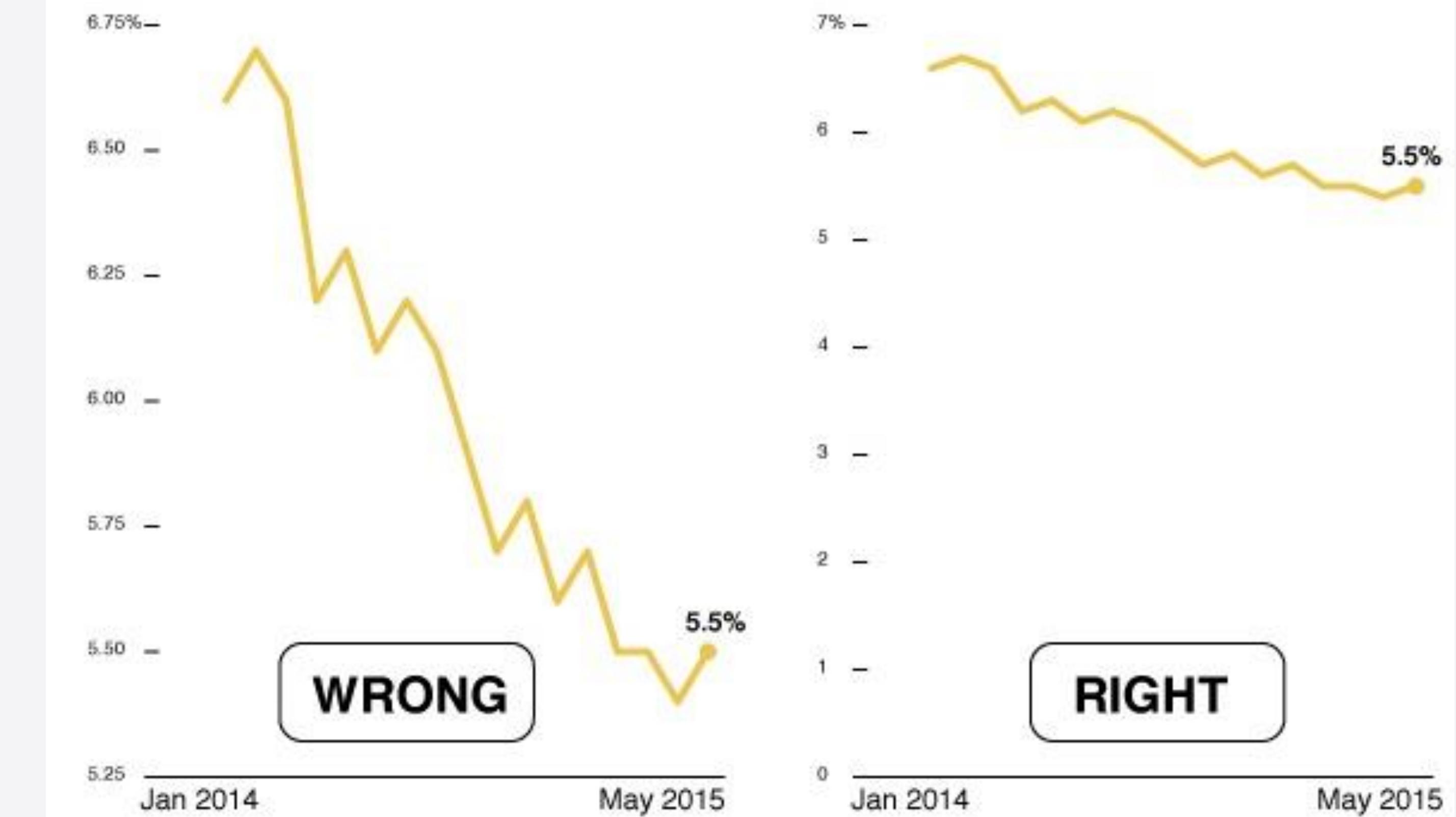
# Ejes



La elección del eje puede enfatizar variación o tendencia

# Ejes

- Linecharts codifican POSICIÓN de puntos
- Barras codifican TAMAÑO
- Las barras necesitan zero baseline, los puntos (linechart) no

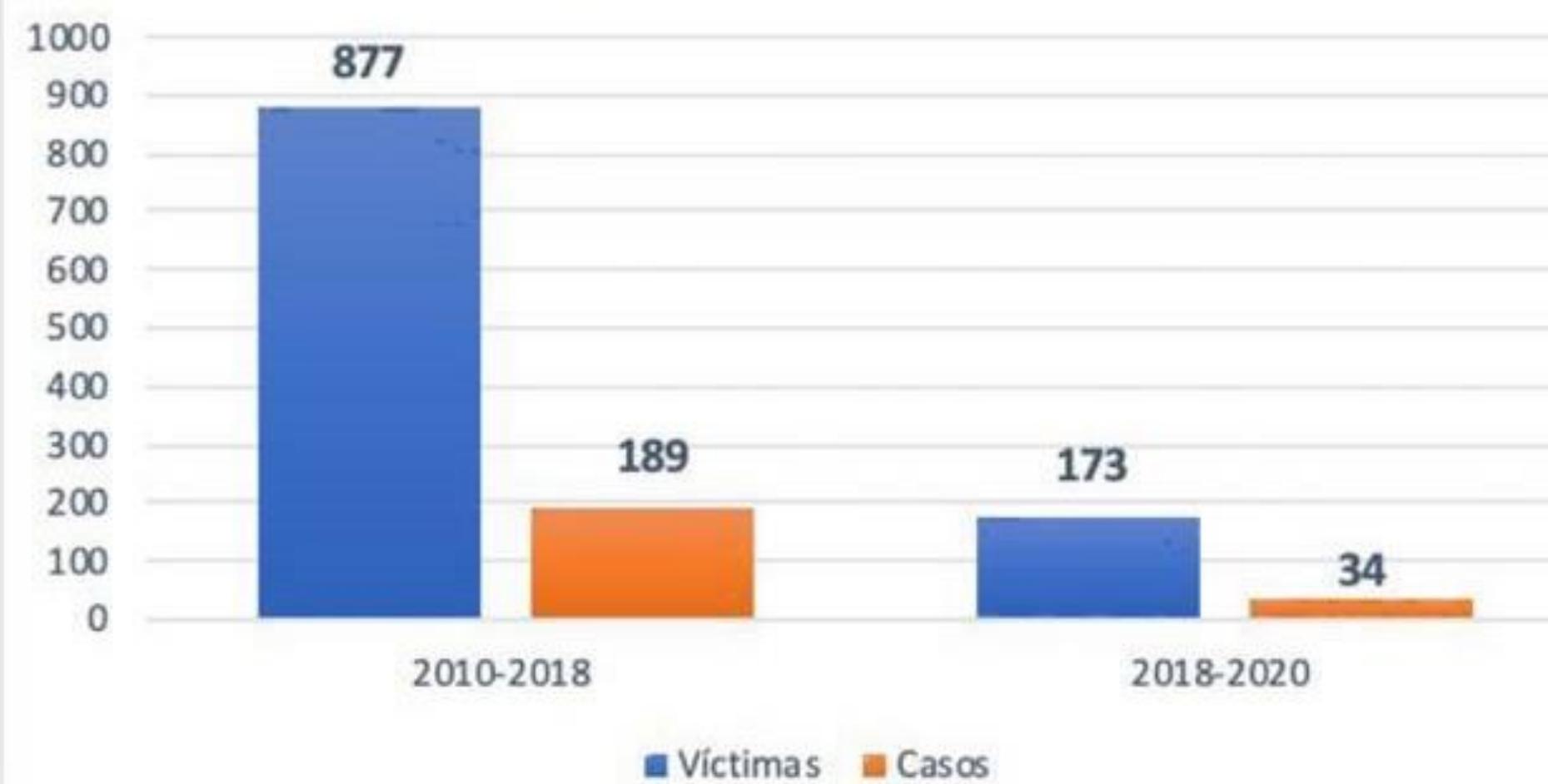


<http://news.nationalgeographic.com/2015/06/150619-data-points-five-ways-to-lie-with-charts/>

# Ejes

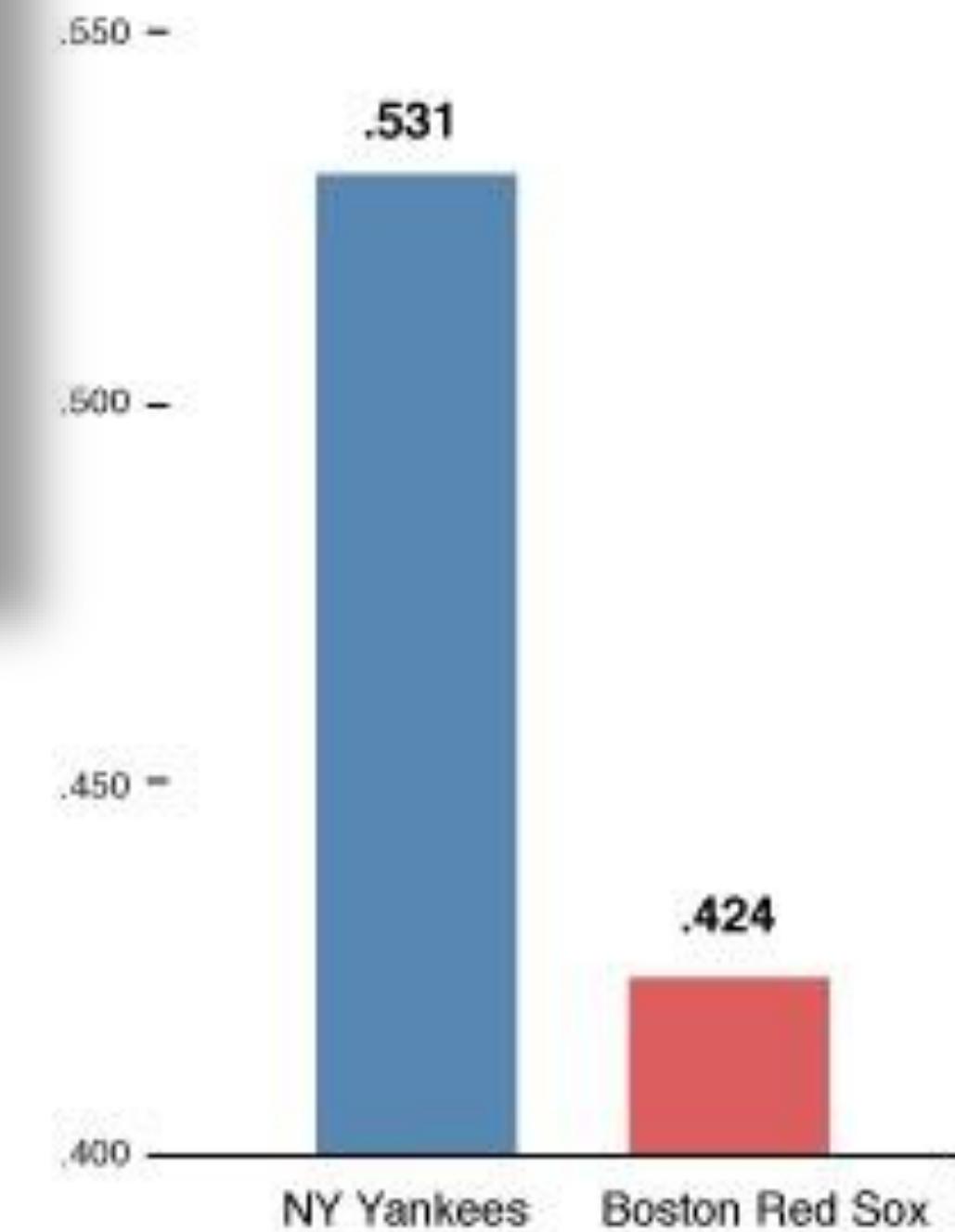
Translate Tweet

## Homicidios Colectivos



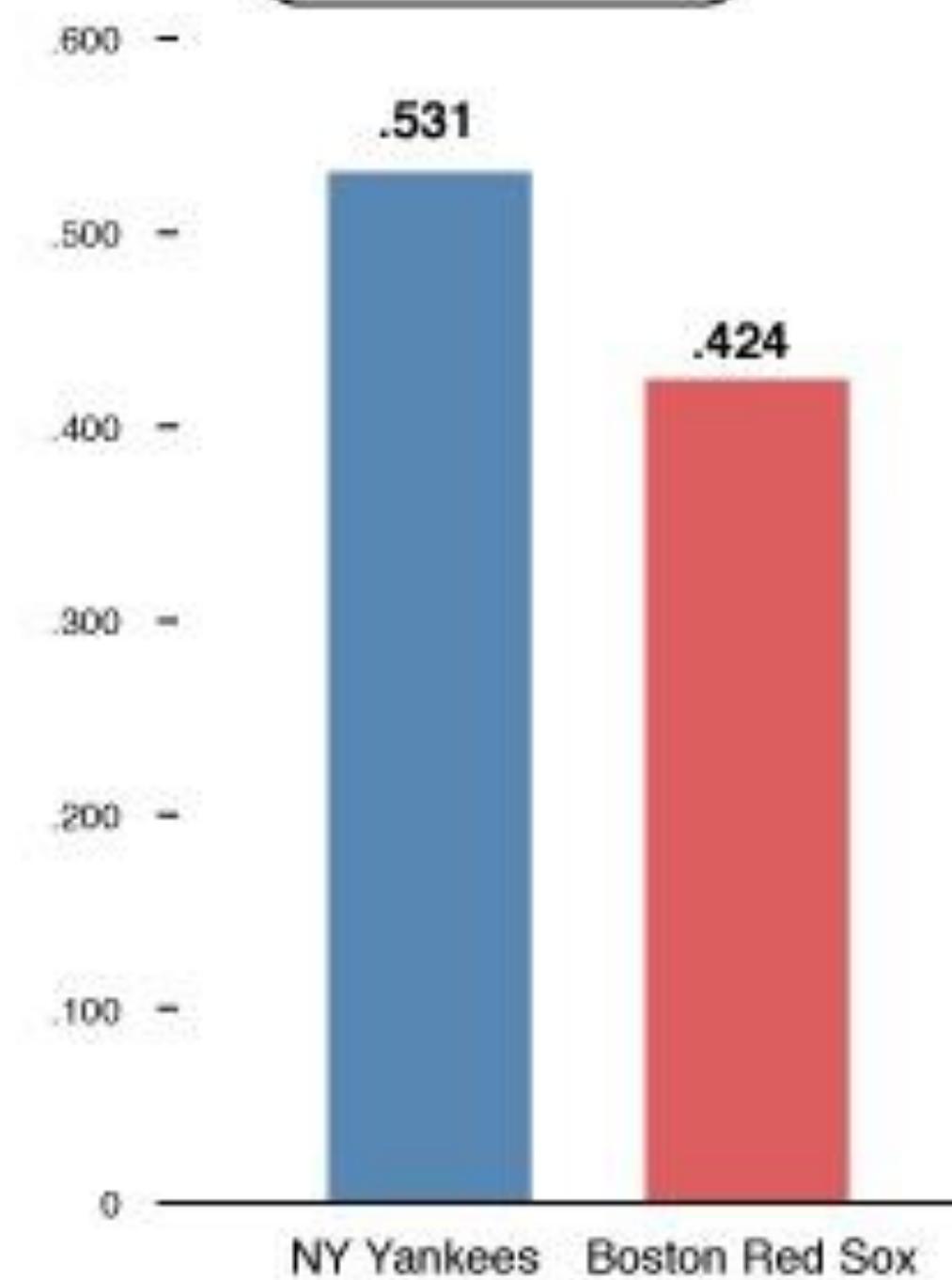
## Percentage of victories

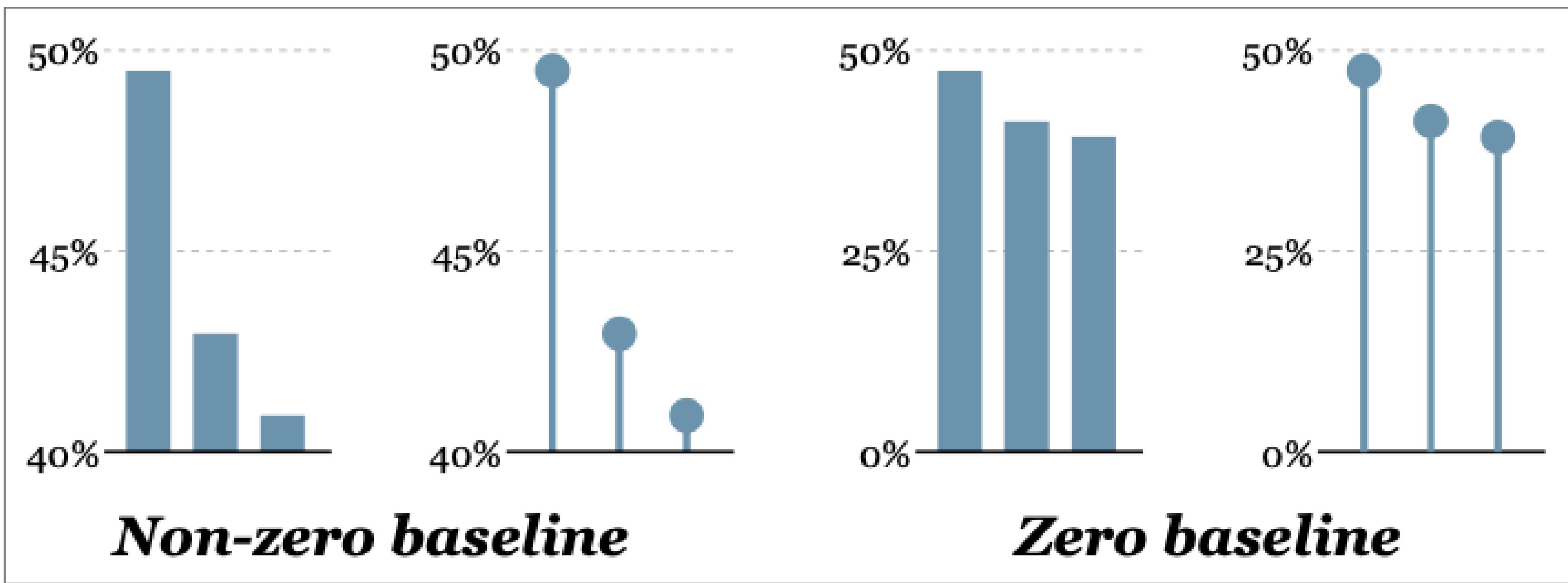
**WRONG**



## Percentage of victories

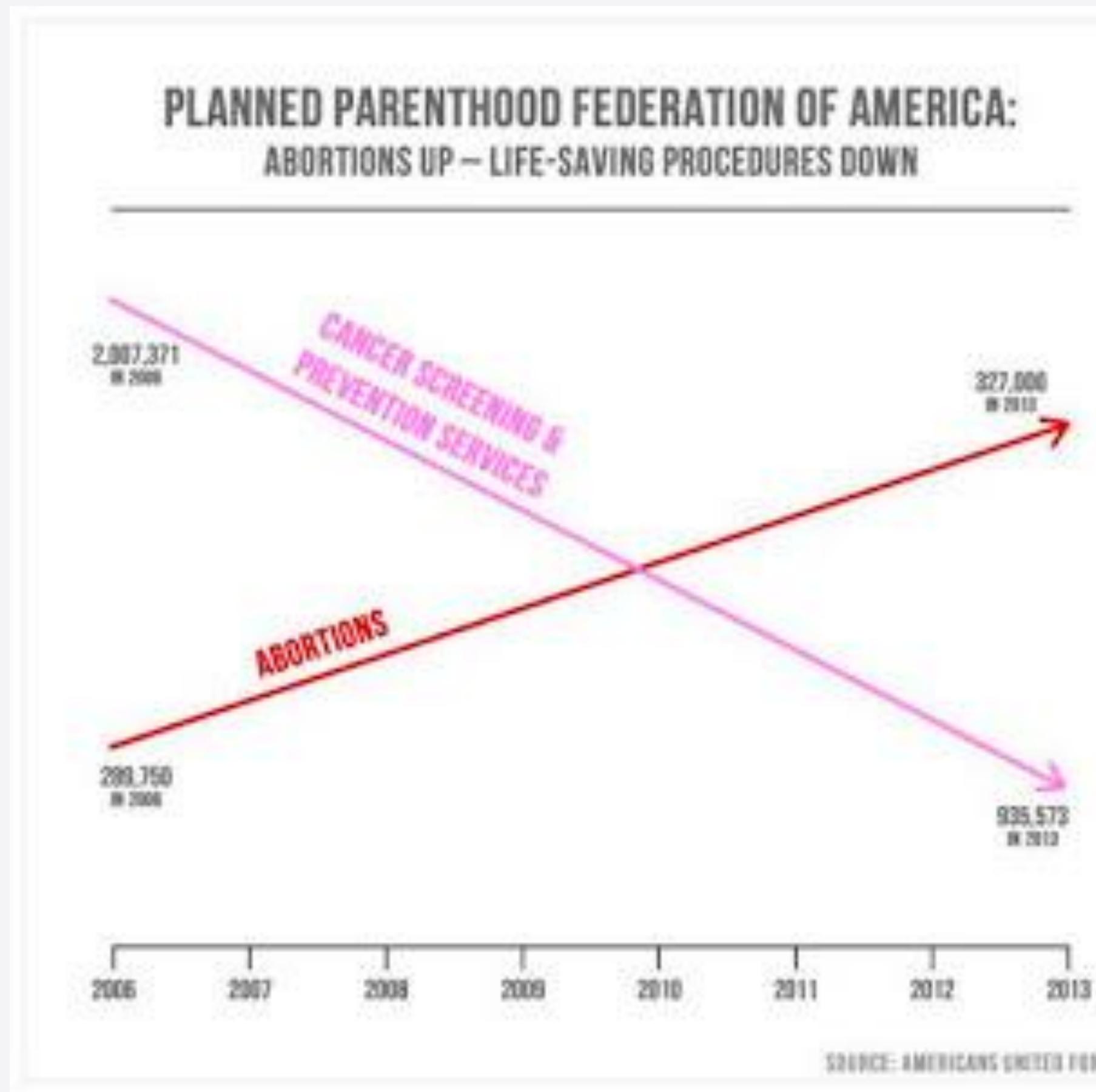
**RIGHT**



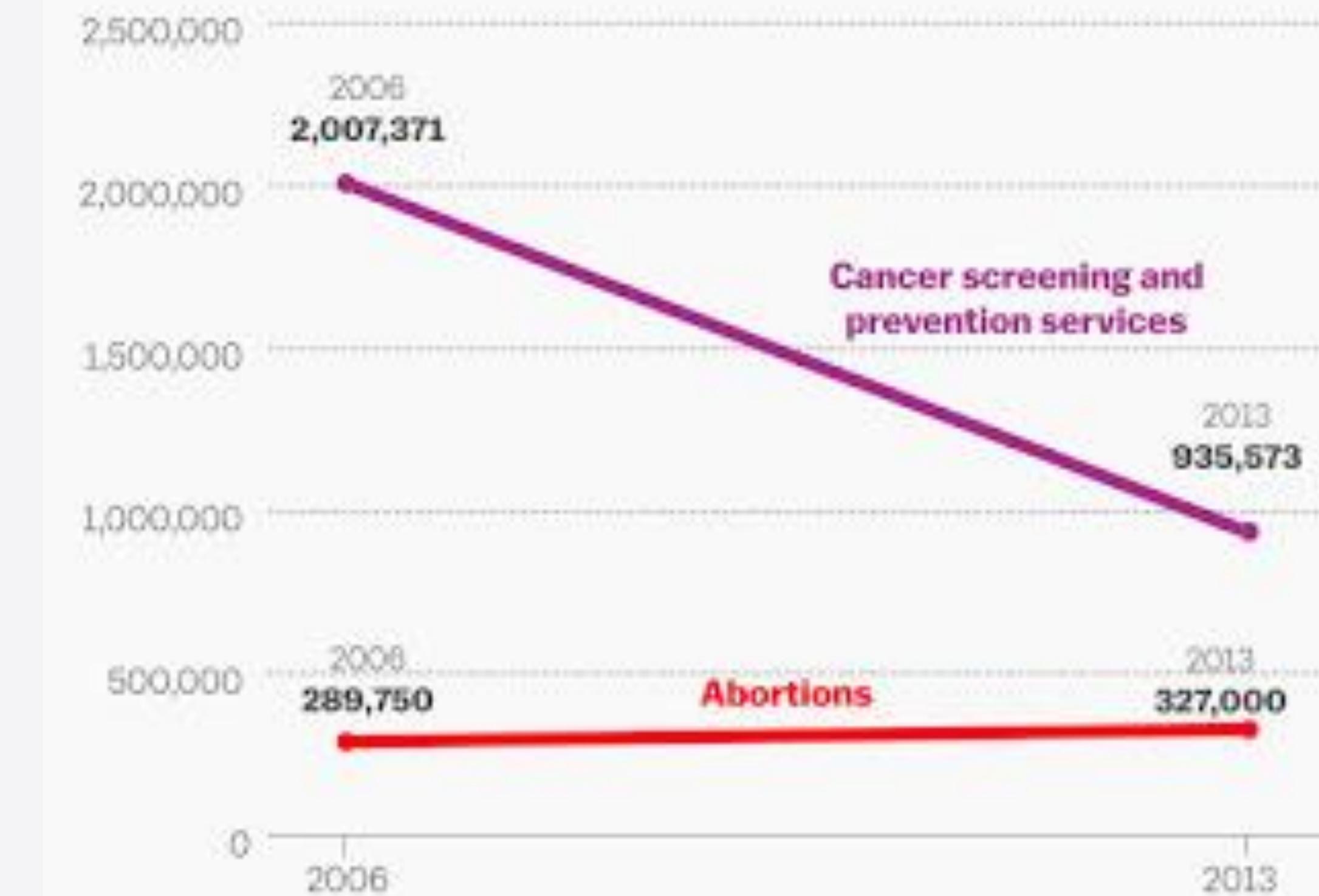


# Ejes

- Labels en los ejes son imprescindibles



**Services provided by Planned Parenthood**

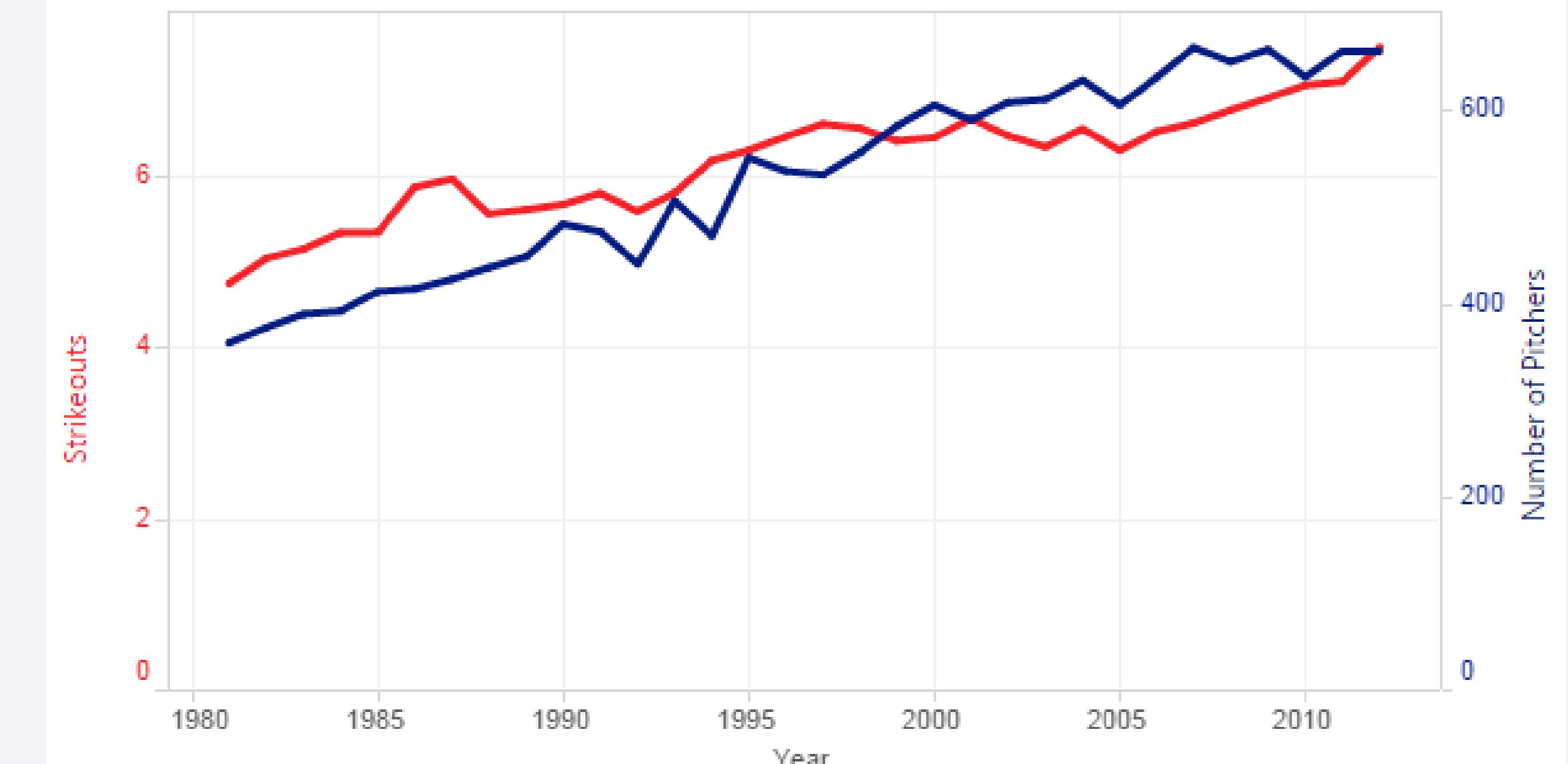


Vox

# Evitar ejes duales

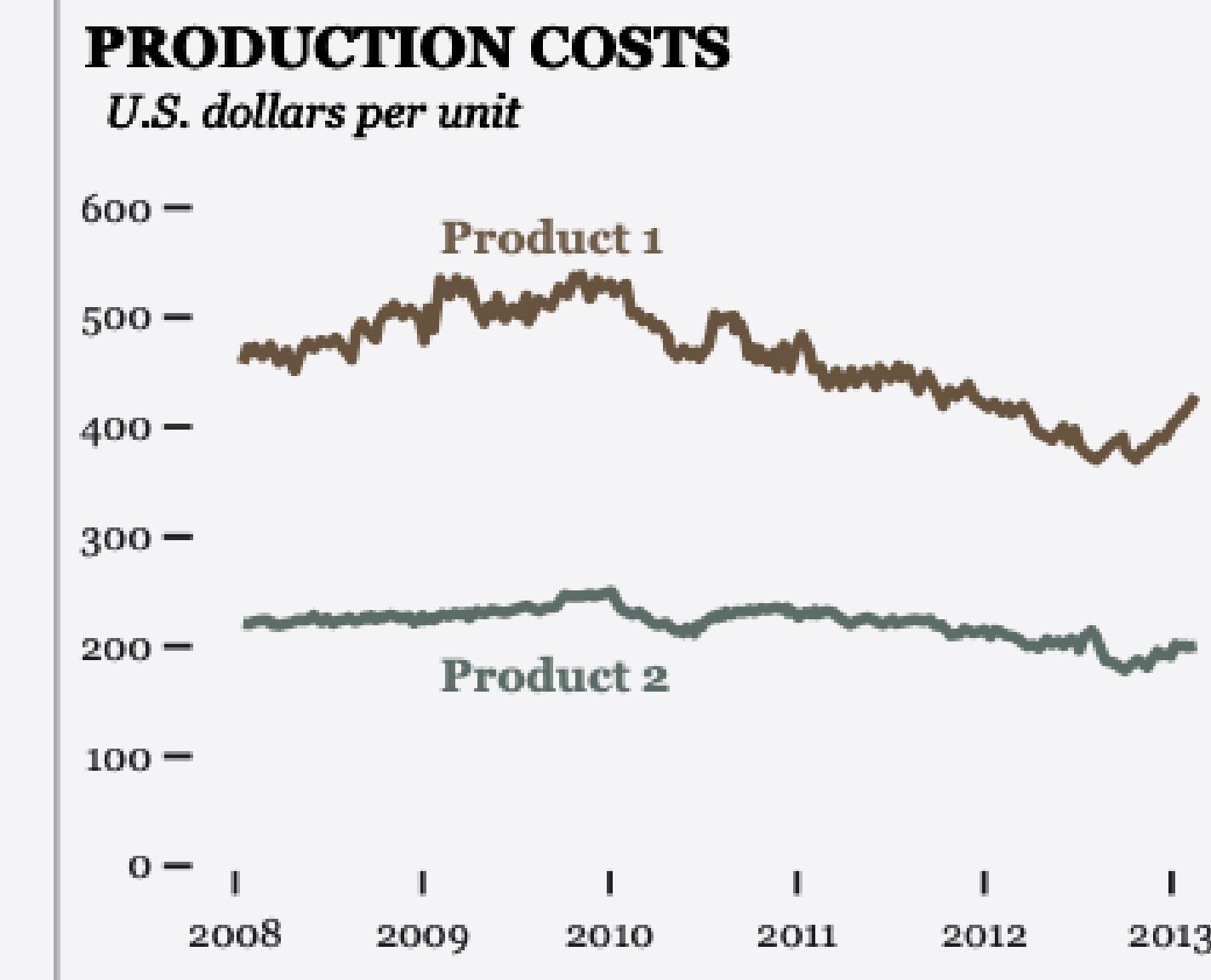
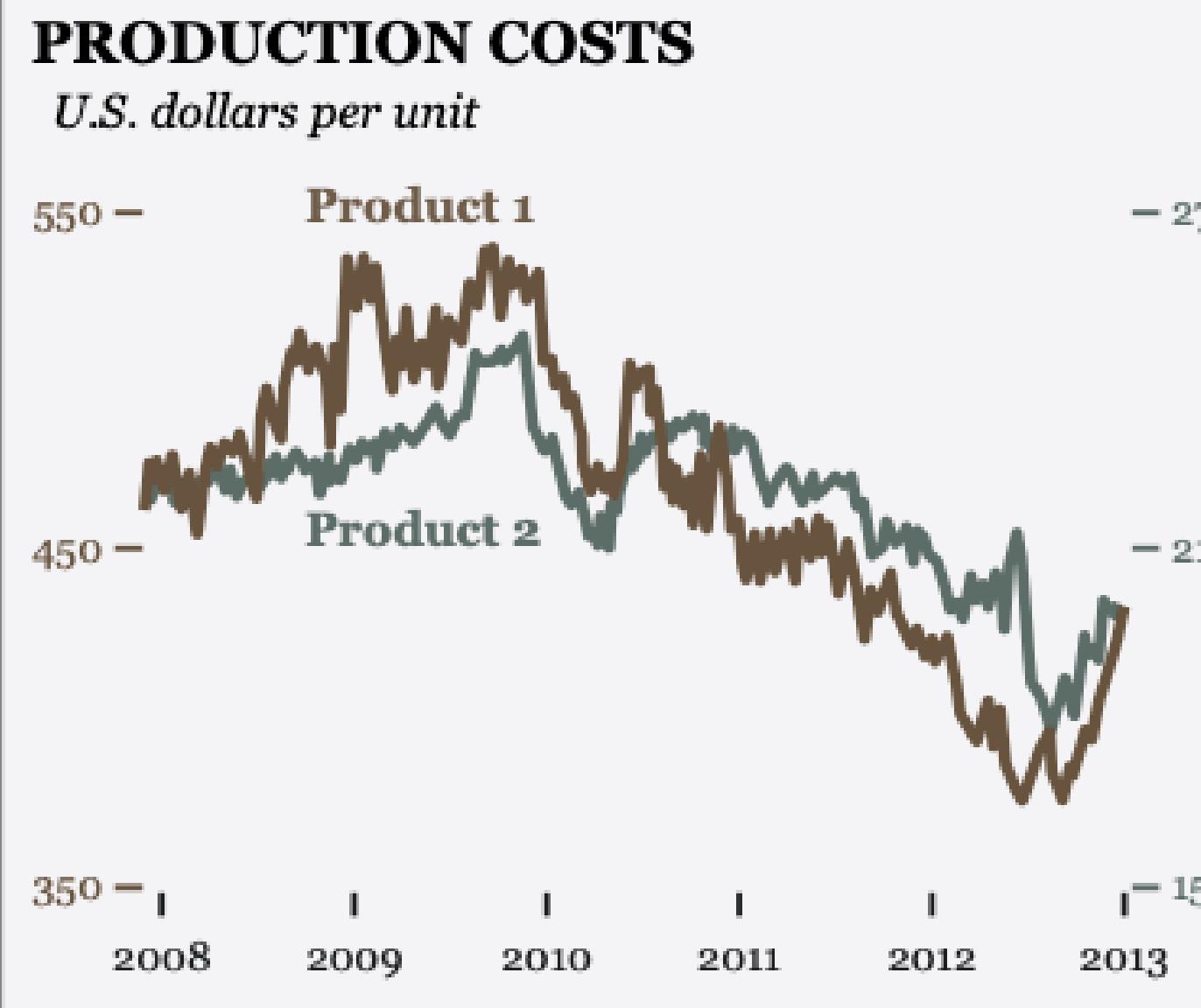
## Problemáticos

- Aceptable en casos muy concretos
- Muy fácil llevar a conclusiones equivocadas:
  - Muestra implícita correlación entre líneas

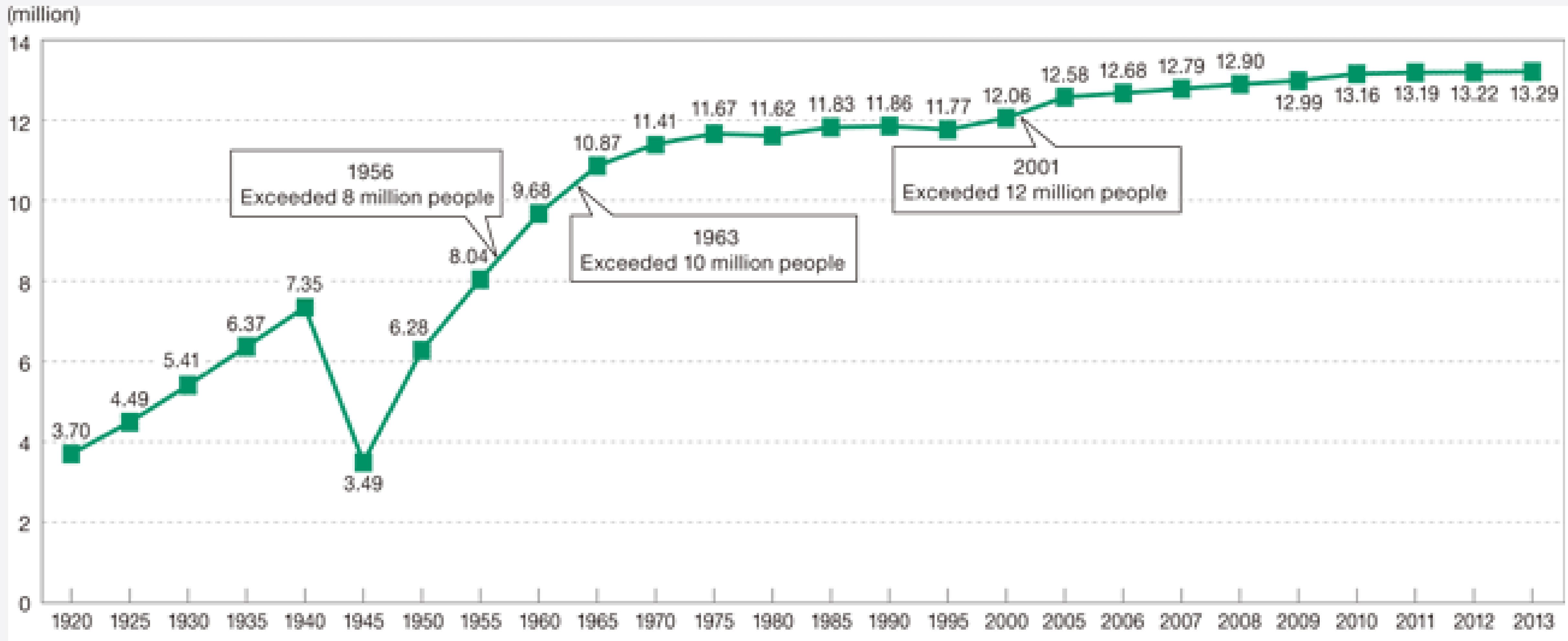


Source | <http://www.baseball-reference.com/leagues/MLB/pitch.shtml> Ben Jones (@DataRemixed) | 5/4/2013

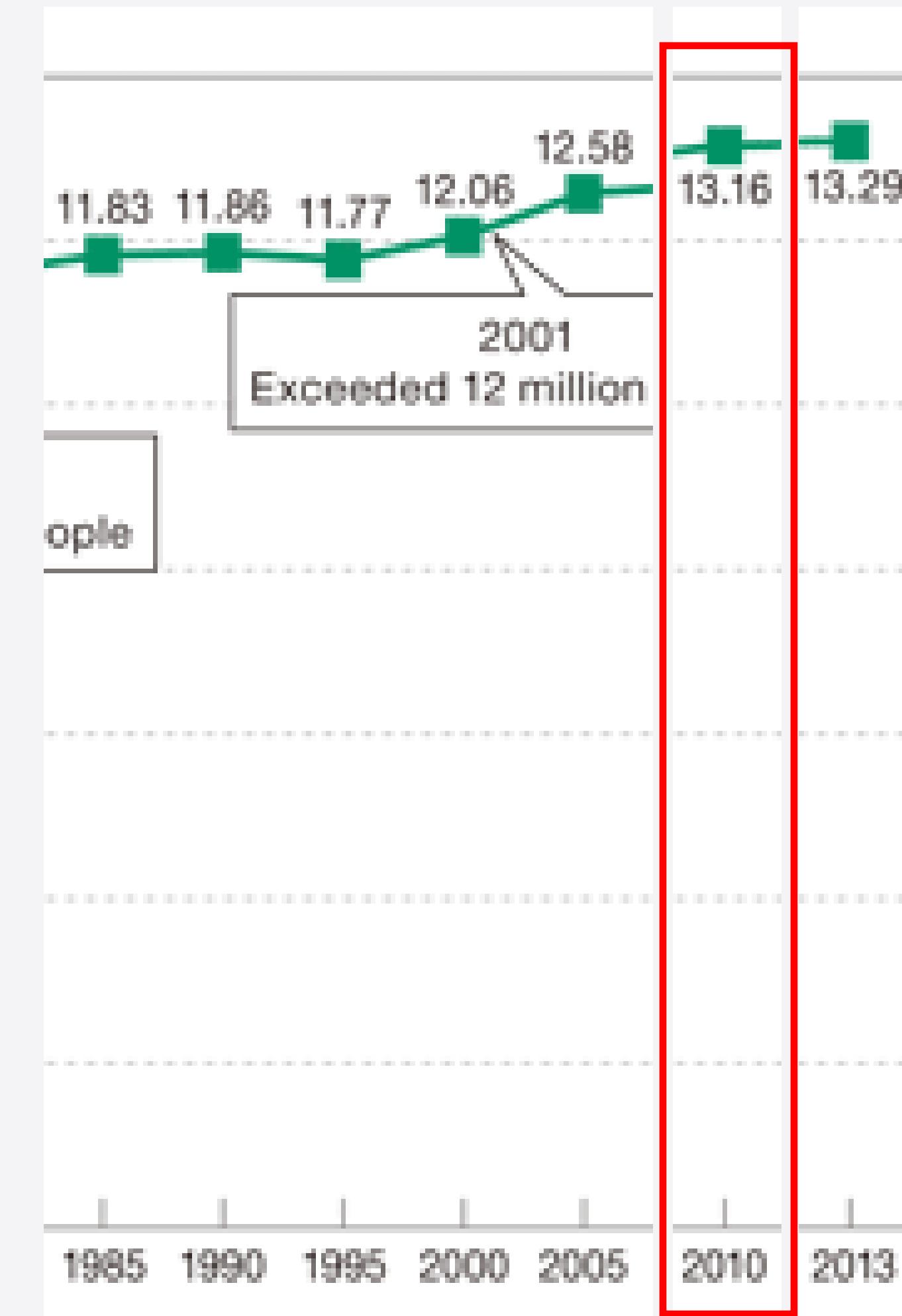
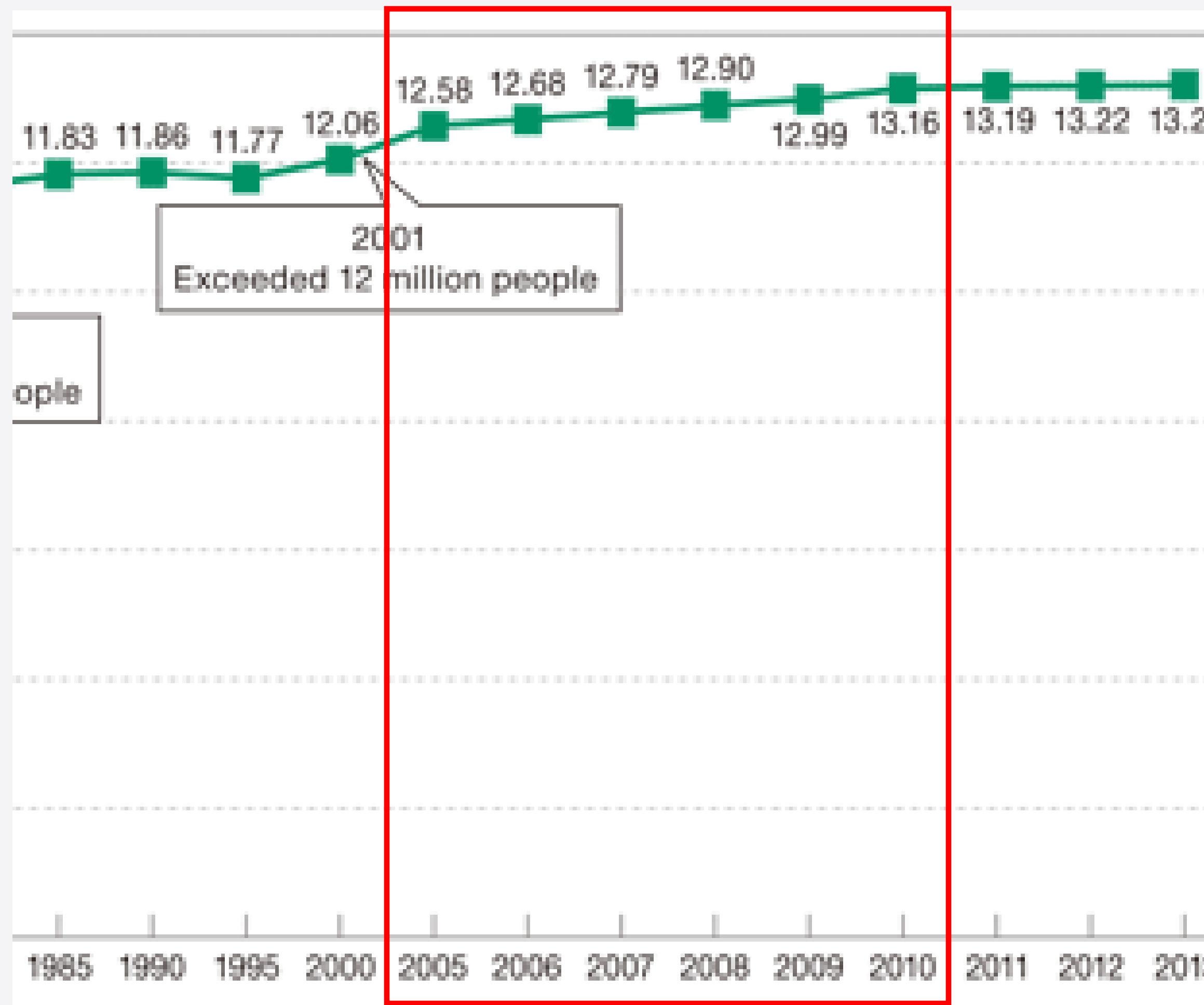
dataremixed.com



# Steps

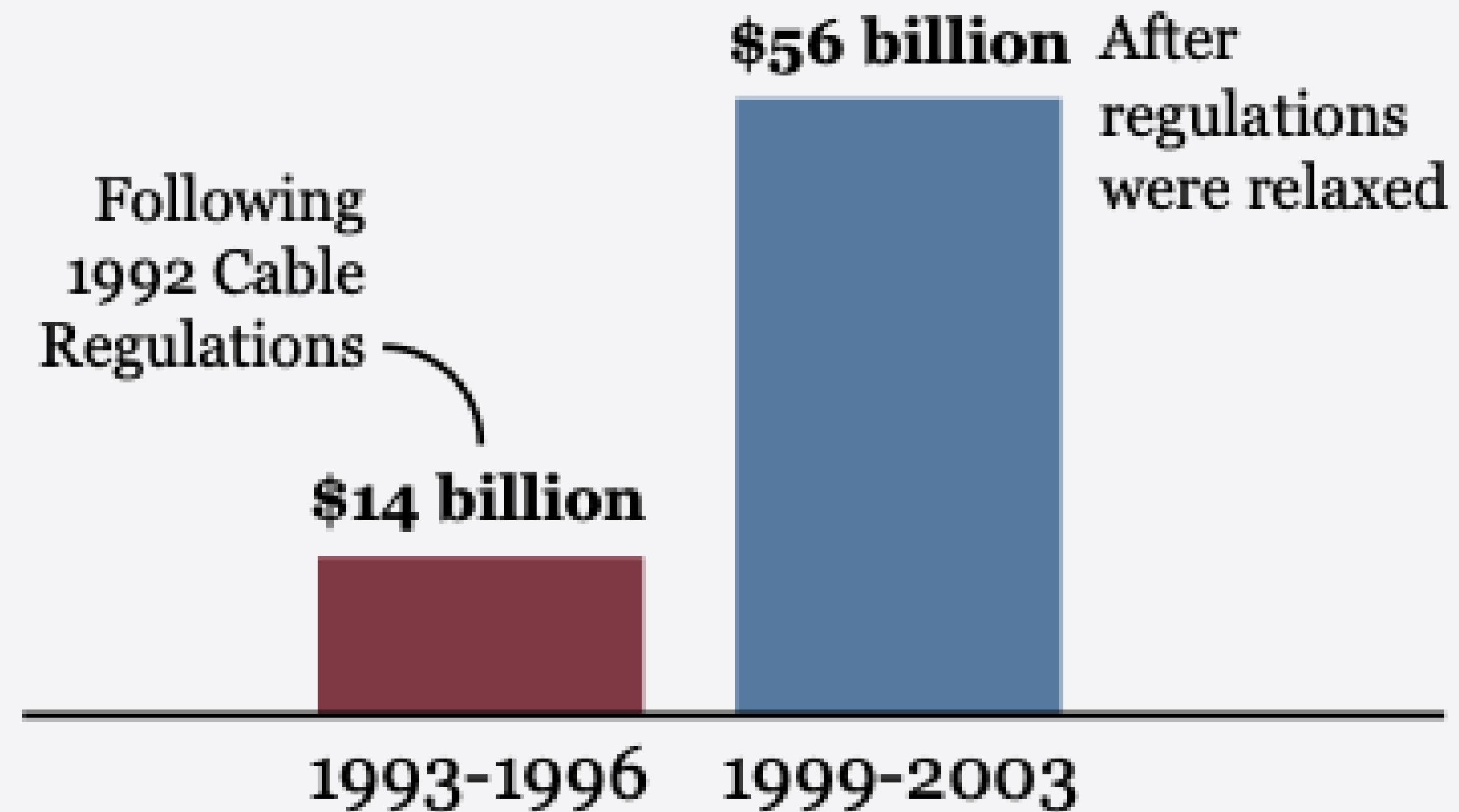


# Steps



# Hacer agregaciones equivalentes

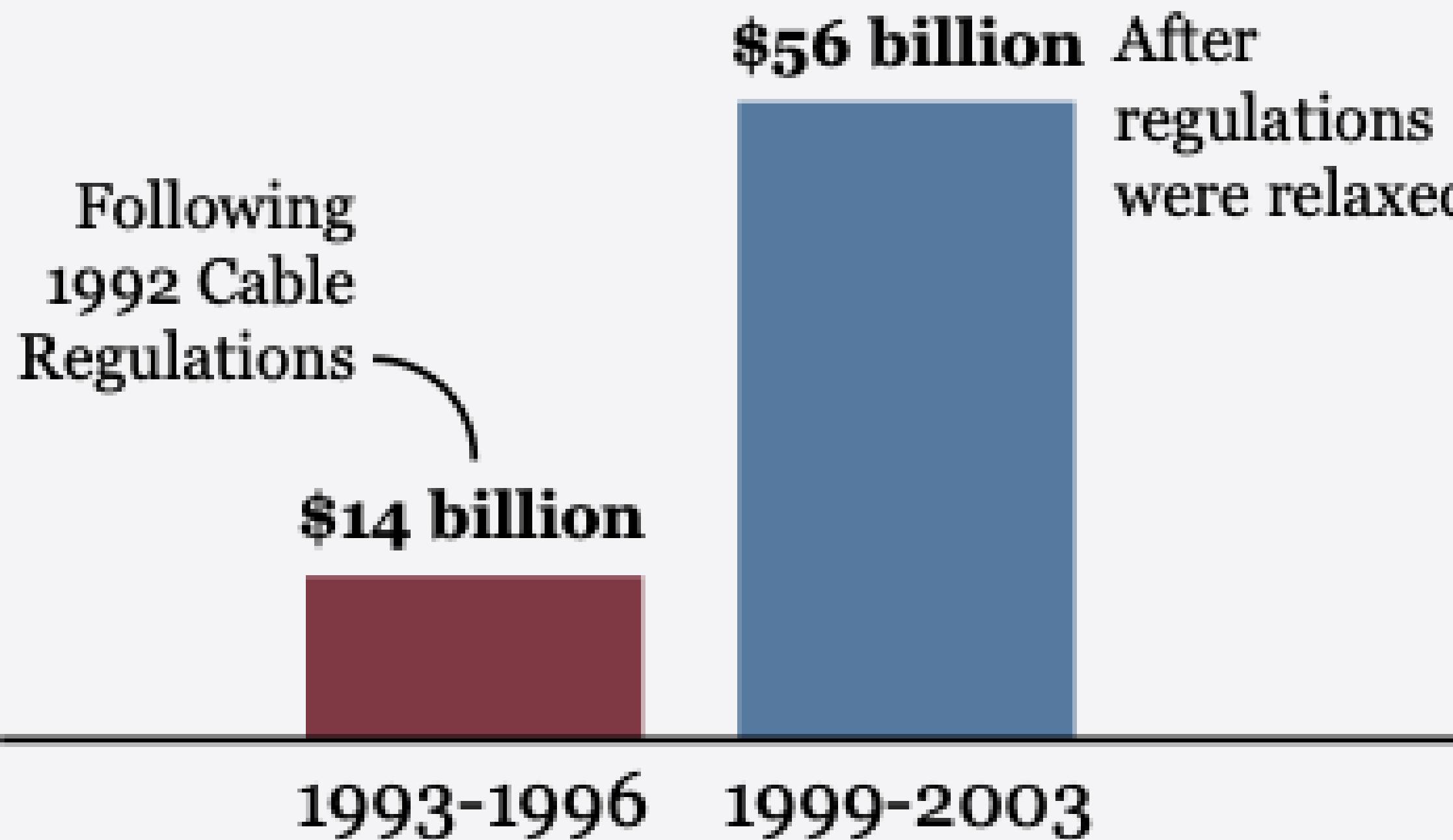
**Less regulation =  
More industry investment**



# Hacer agregaciones equivalentes

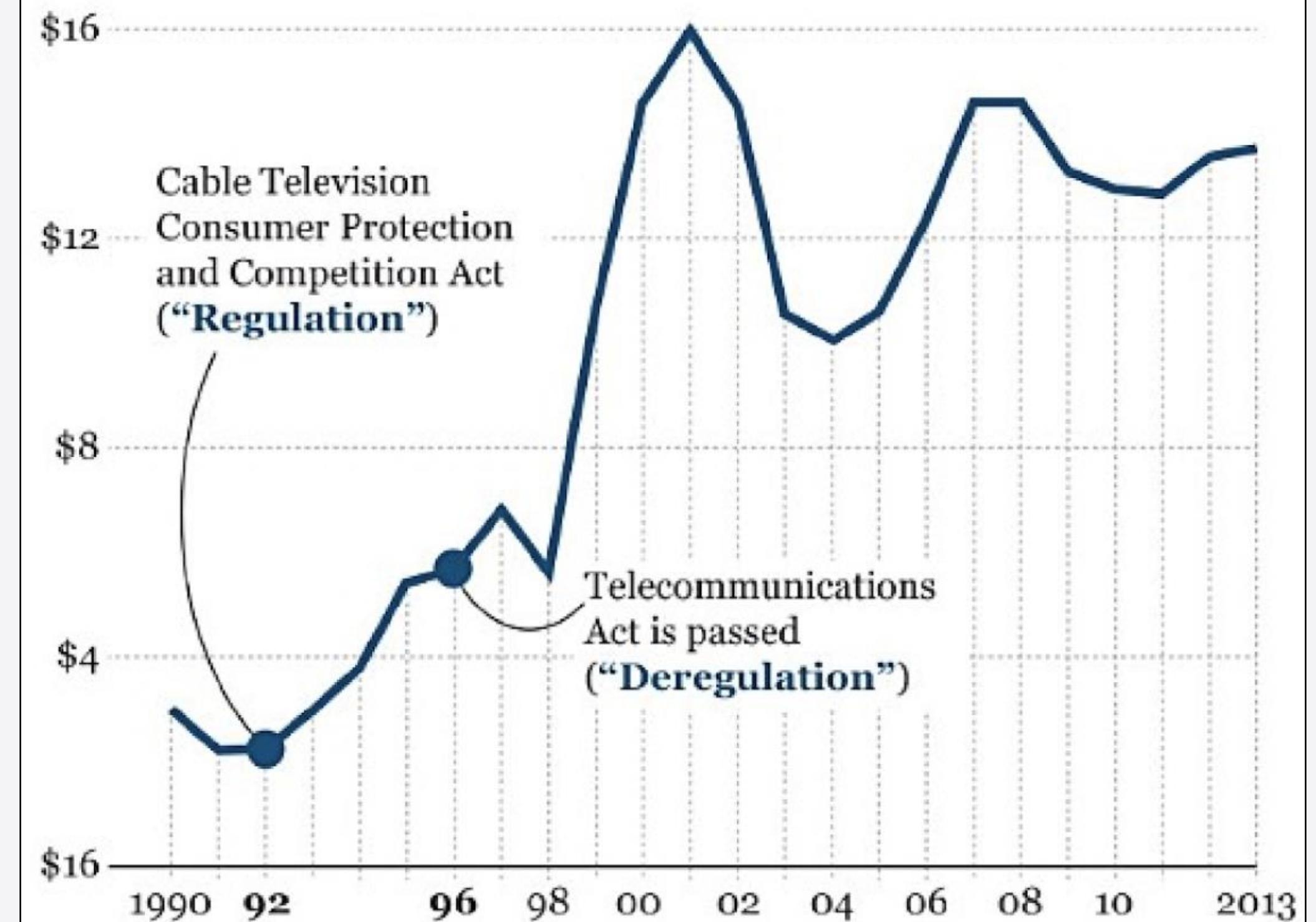
**Less regulation =**

**More industry investment**



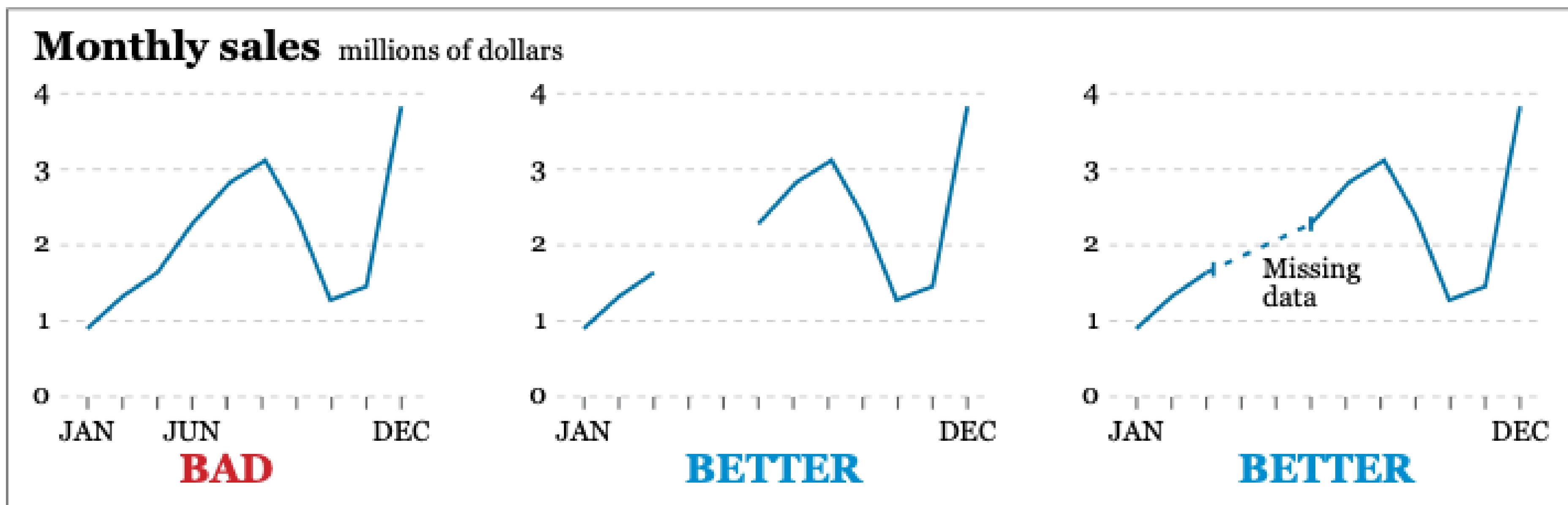
## Cable Industry Infrastructure Expenditures

*In billions*



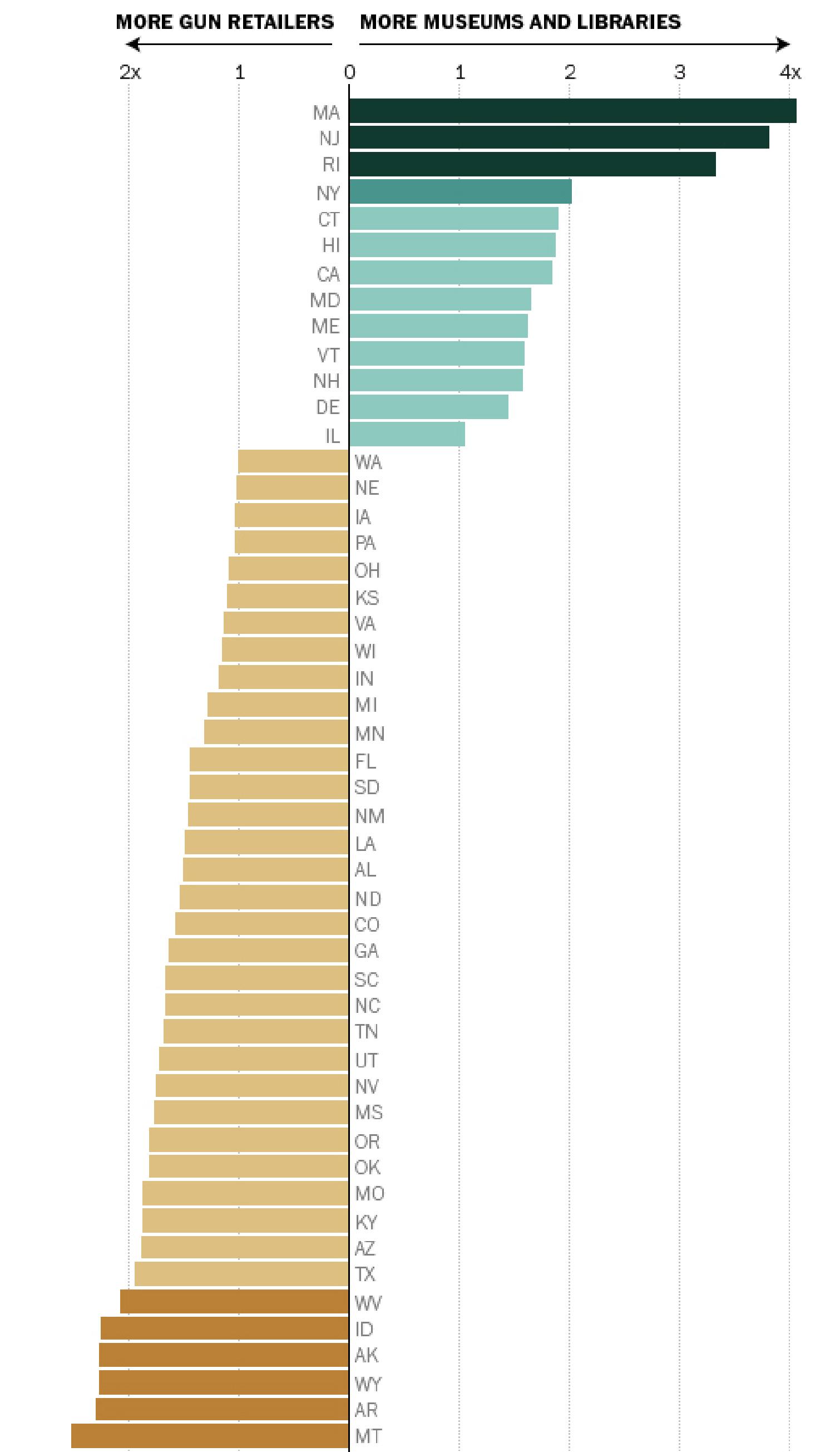
# Missing data

- Marcar explícitamente donde no hay datos
- Mantener el espacio de las marcas / usar marcas distintas



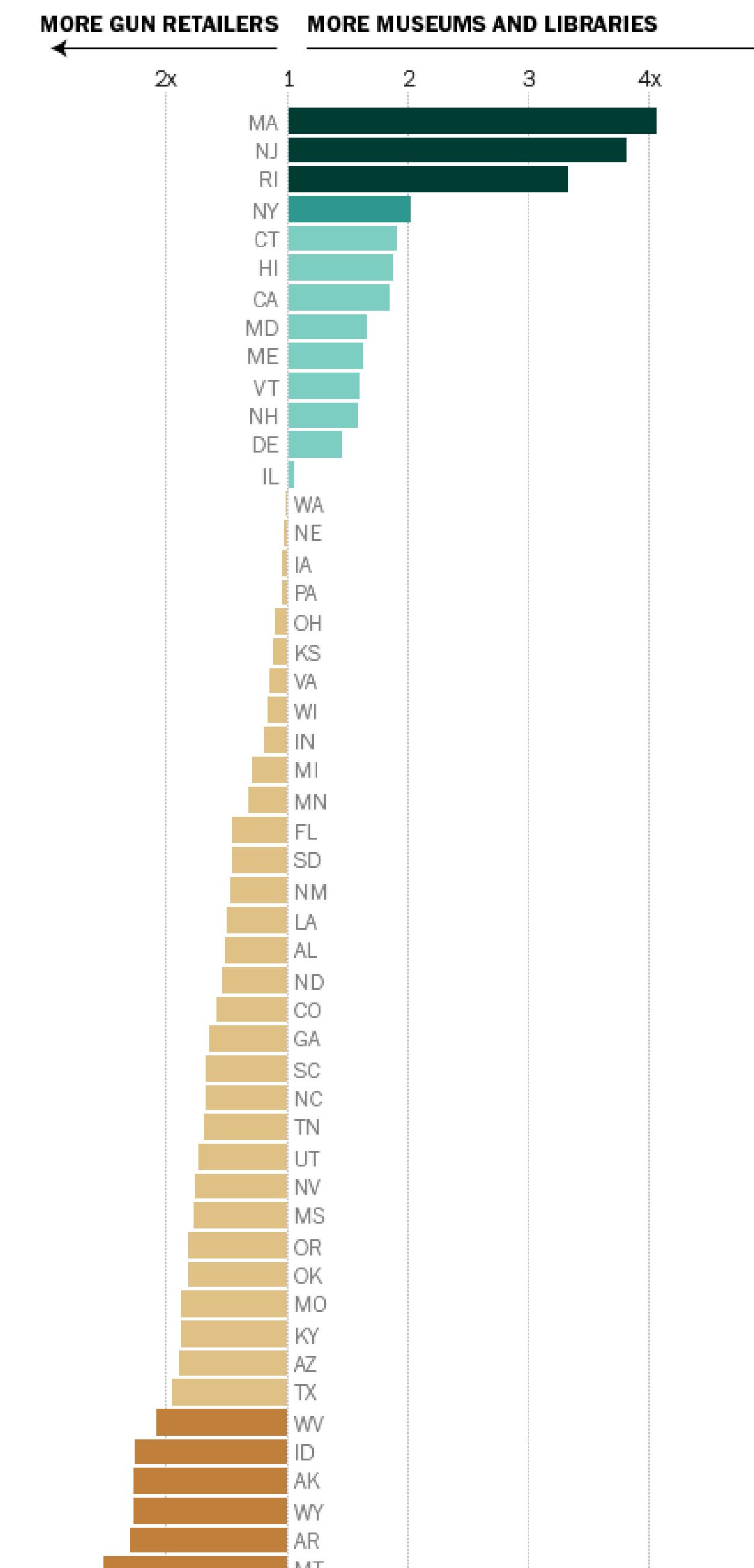
# Baseline

In 37 states, gun dealers outnumber museums and libraries



SOURCE: Institute of Museum and Library Sciences; Bureau of Alcohol, Tobacco and Firearms.  
GRAPHIC: The Washington Post. Published June 17, 2014

In 37 states, gun dealers outnumber museums and libraries



SOURCE: Institute of Museum and Library Sciences; Bureau of Alcohol, Tobacco and Firearms.  
GRAPHIC: The Washington Post. Published June 17, 2014

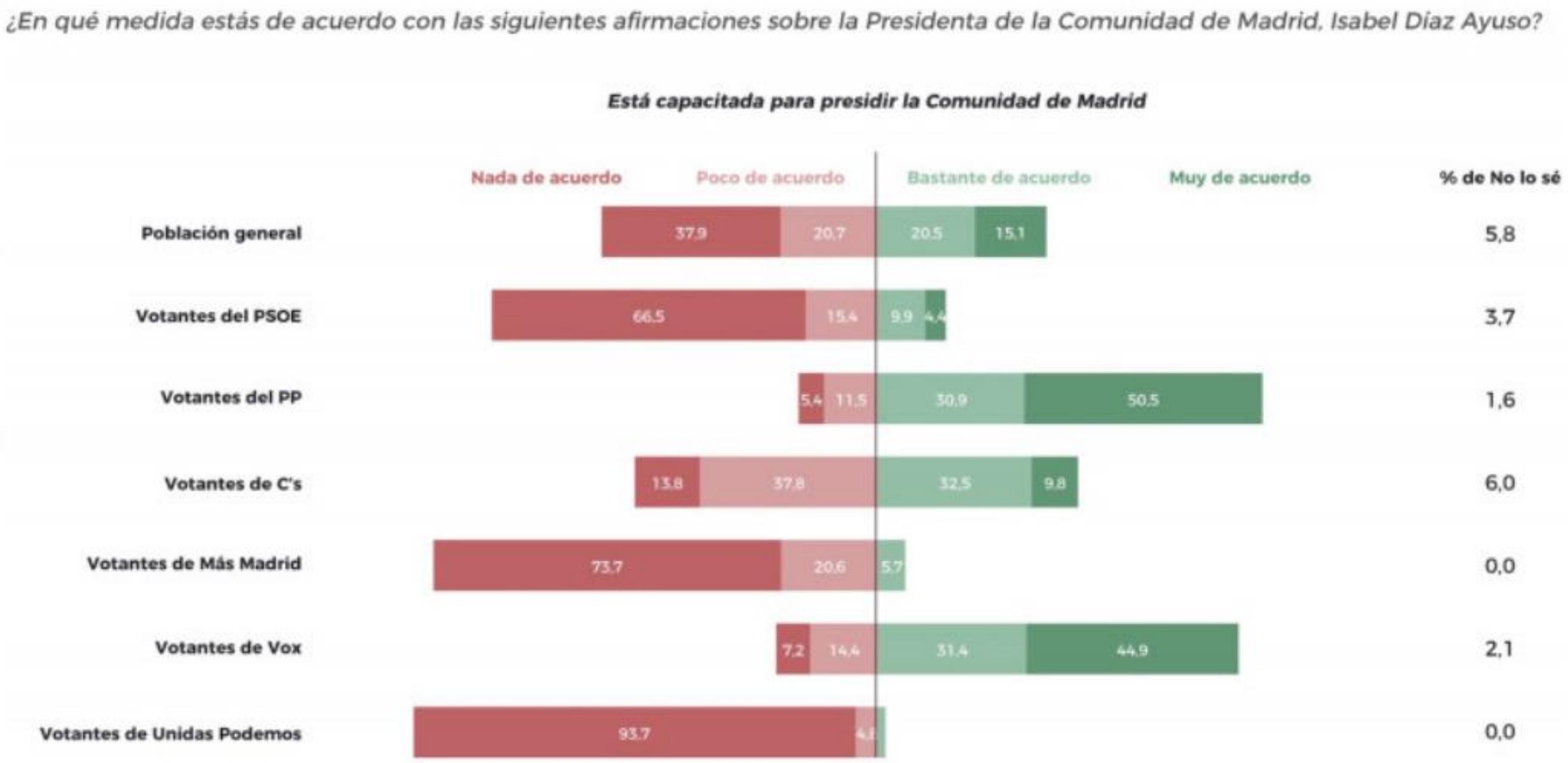
# Stacked bars no alineadas

- Problemático. Difícil comparar porcentajes
- Difícil identificar 50%

Más del 50% de los electores de C's suspenden a la presidenta de la Comunidad y al Gobierno regional de su propio partido. El 51,1% de los madrileños, a favor de un cambio. Sánchez sale peor parado que la líder popular

ctxt 6/02/2021

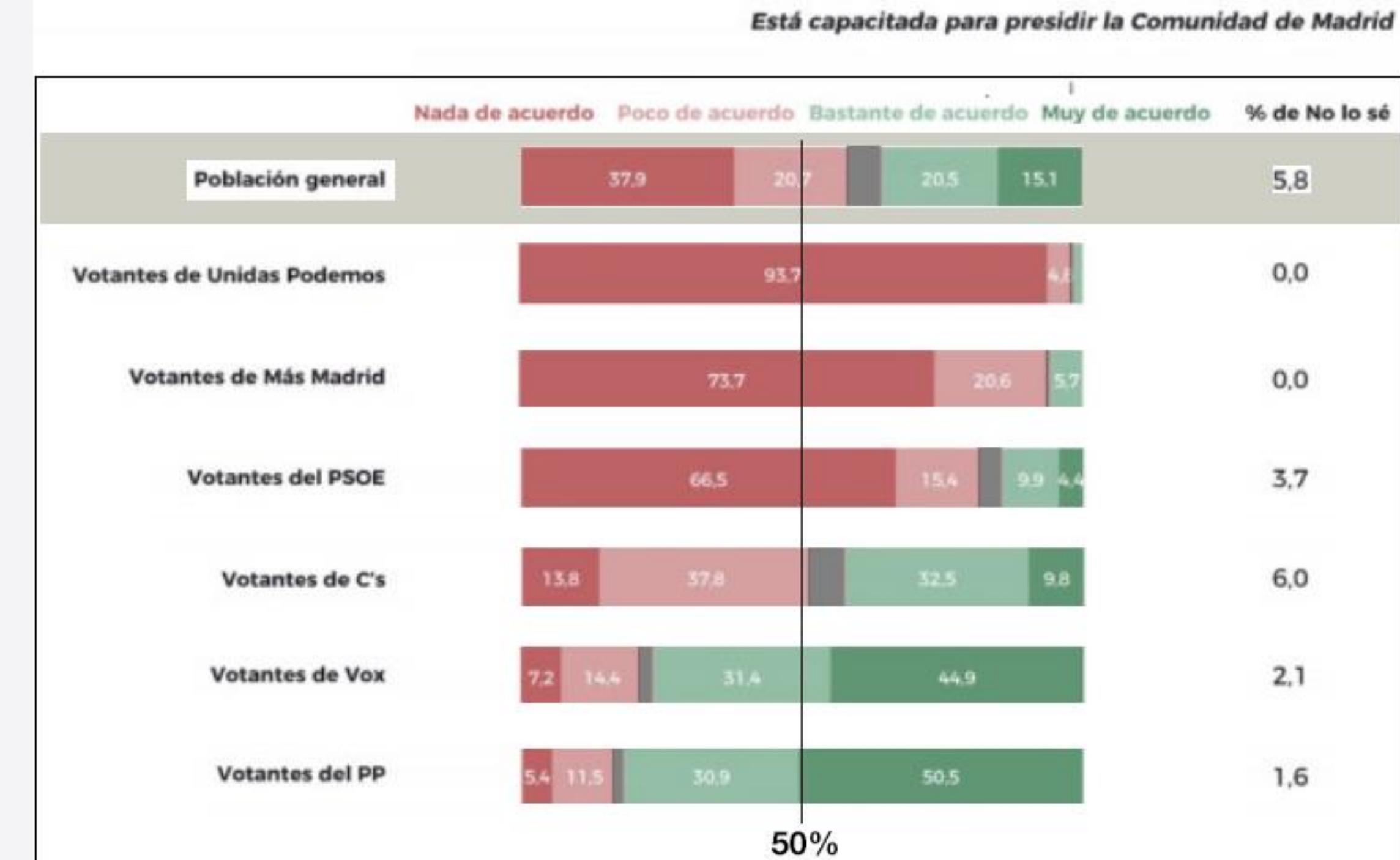
## Sobre Isabel Díaz Ayuso



40dB.

ctxt  
REVISTA CONTEXTO

## Sobre Isabel Díaz Ayuso

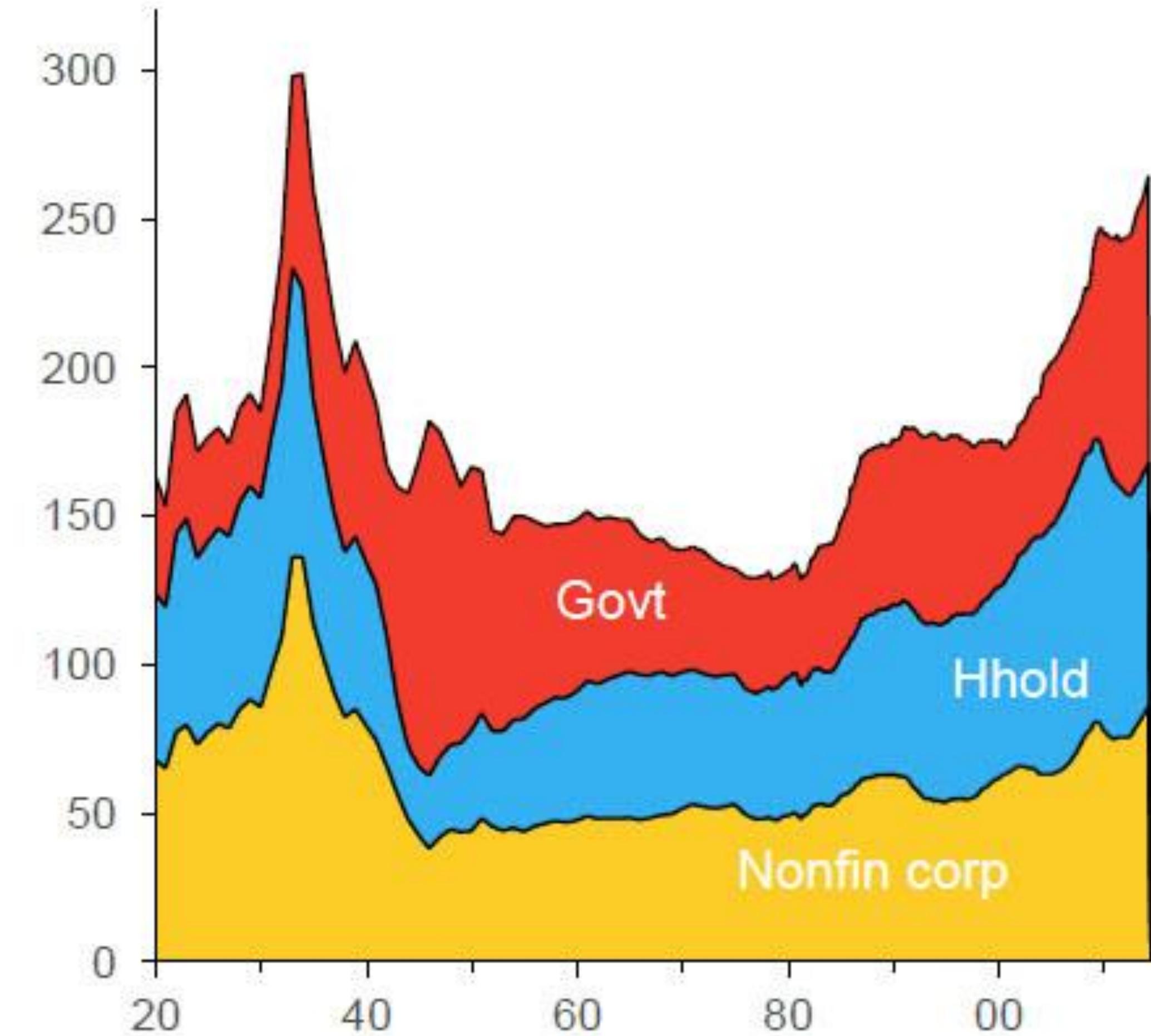


# Precisión en area charts

- Mensaje: Niveles de deuda actuales similares a 1930s pero...
- Muy difícil identificar que categoría es responsable del aumento.
- ¿Otras relaciones entre ellas?

More debt = stronger wealth effects

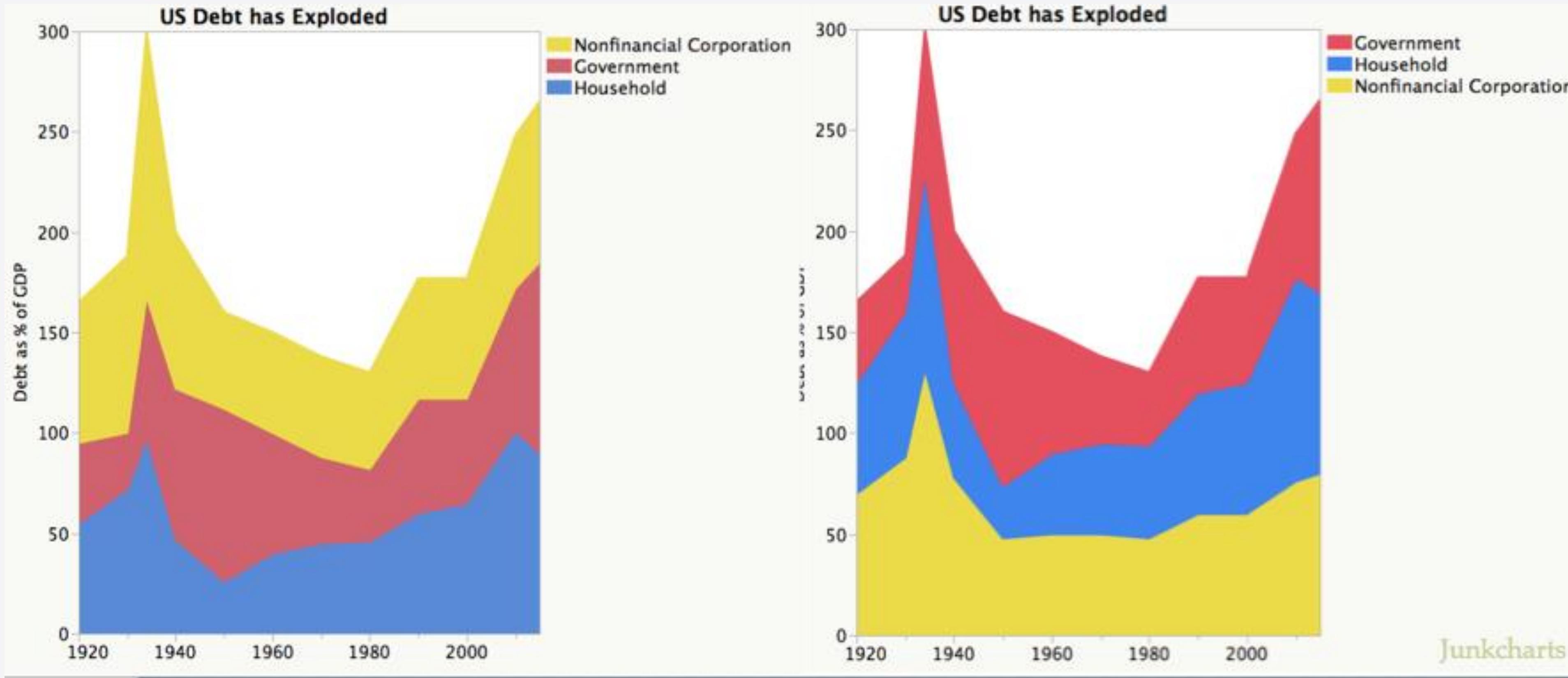
US debt across non-fin sectors, % GDP



Source: Federal Reserve.

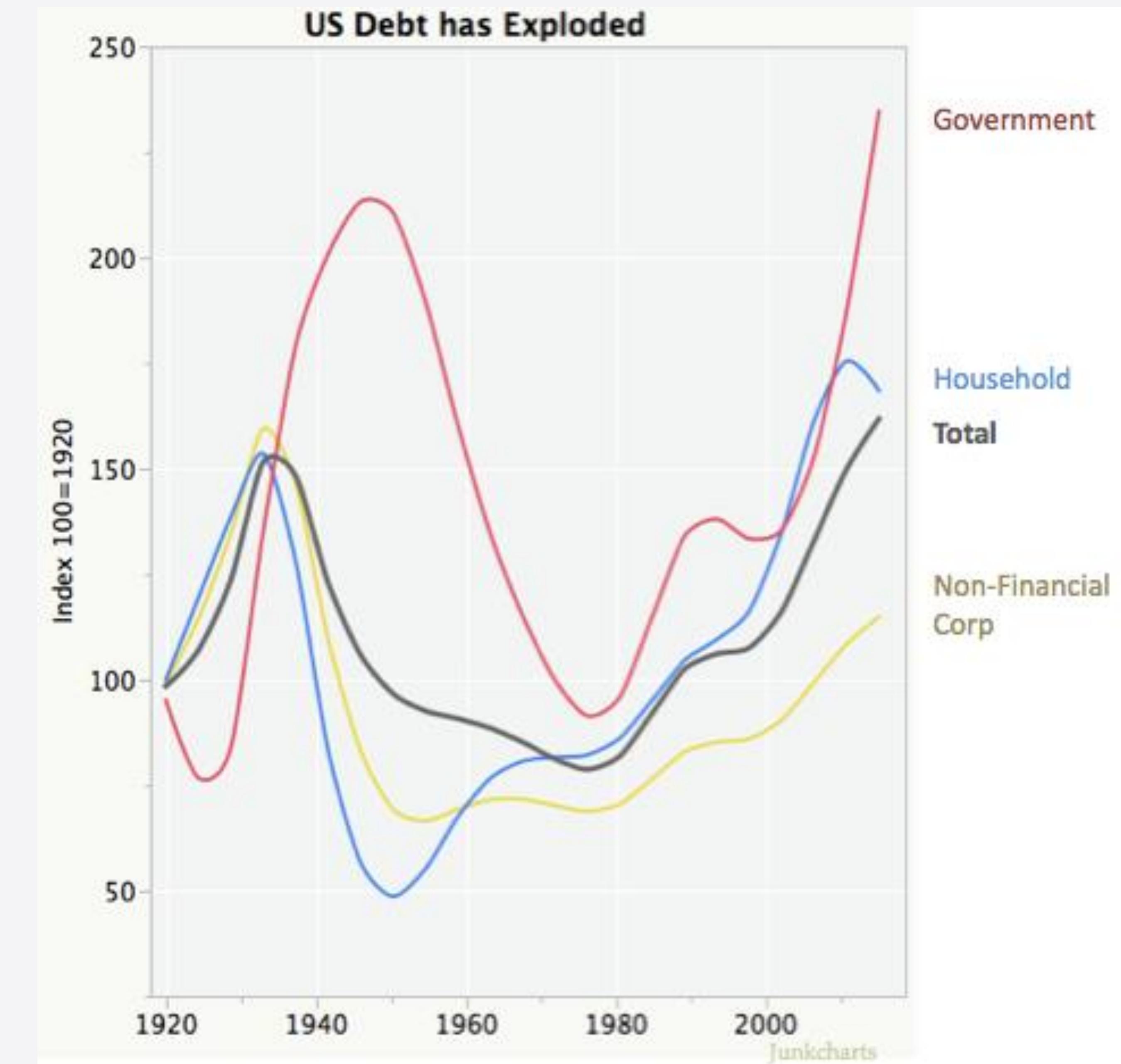
# Precisión en area charts

- Dos opciones de 6 posibles
- Picos en capas superiores tienden a magnificarse



# Precisión en area charts

- Solución: no usar área chart
- Calcular índices usando la media de 1920 como referencia

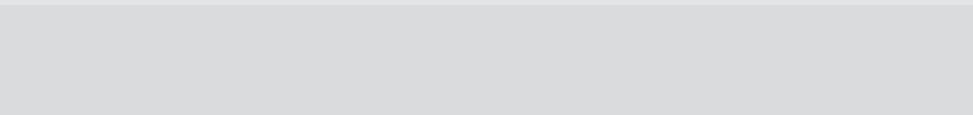


# Elegir métricas relevantes

## Most dangerous cities

Total murders in 2014

Chicago



407

New York

328

Detroit

304

Los Angeles

259

Philadelphia

248

# Elegir métricas relevantes

## Most dangerous cities

Total murders in 2014

Chicago

407

New York

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Detroit

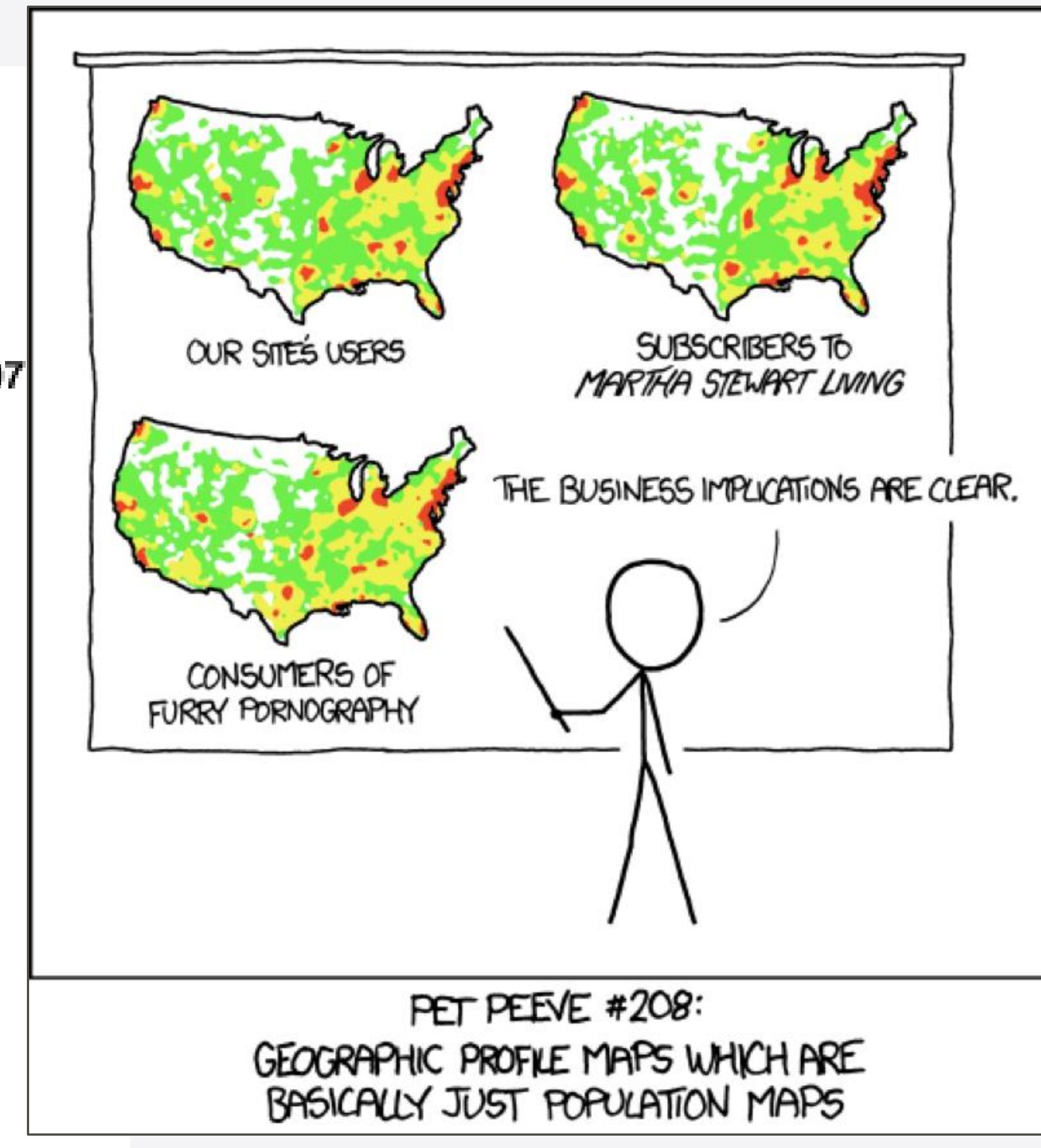
304

Los Angeles

259

Philadelphia

248



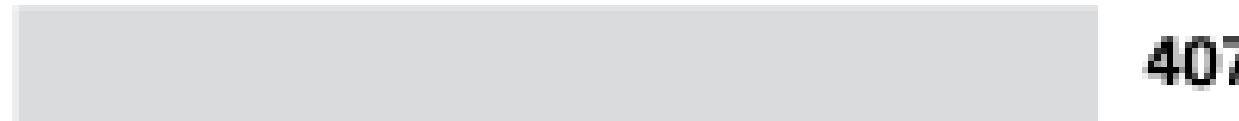
[ <https://xkcd.com/1138> ]

# Elegir métricas relevantes

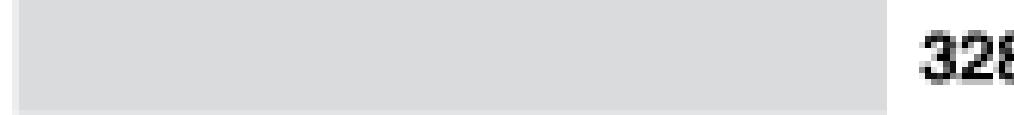
## Most dangerous cities

Total murders in 2014

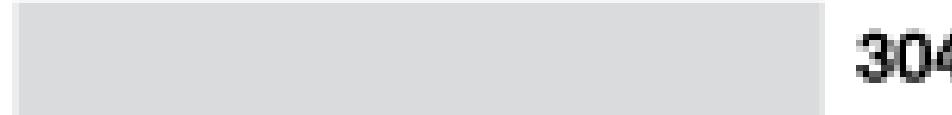
Chicago



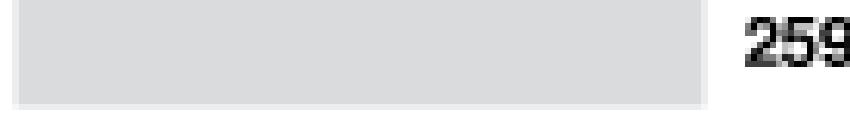
New York



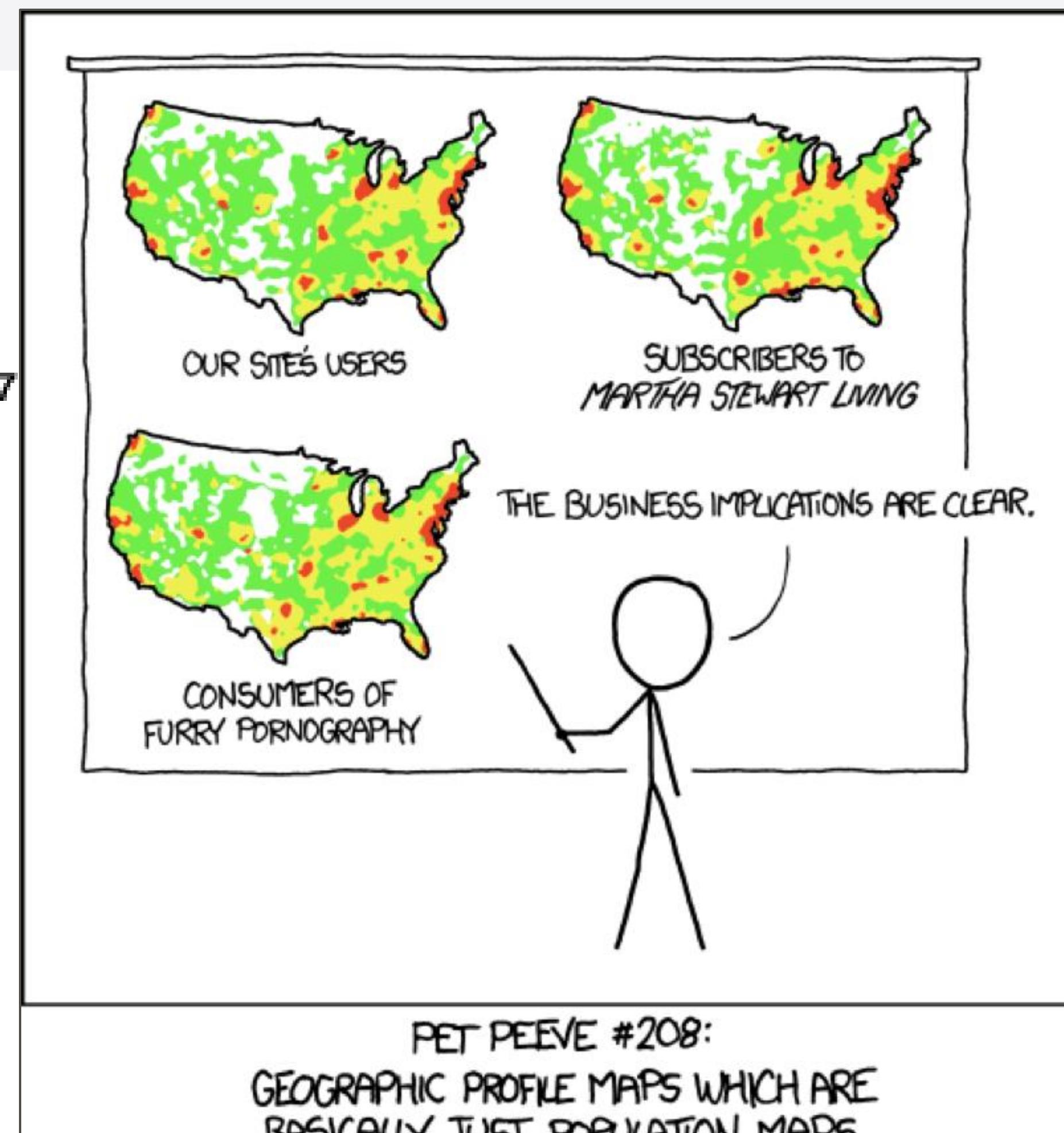
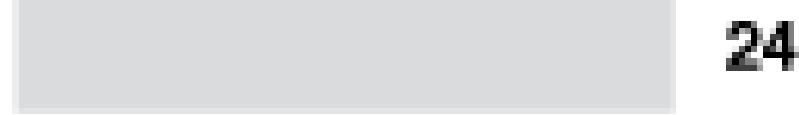
Detroit



Los Angeles



Philadelphia



[ <https://xkcd.com/1138> ]

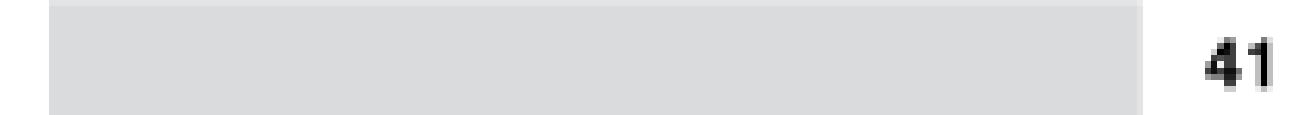
## Most dangerous cities

Murder rate in major US cities in 2014, per 100,000 people

Detroit



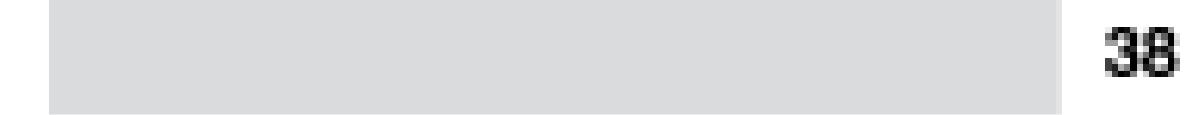
New Orleans



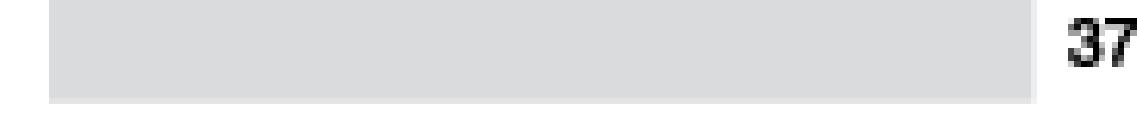
Newark



St. Louis



Baltimore

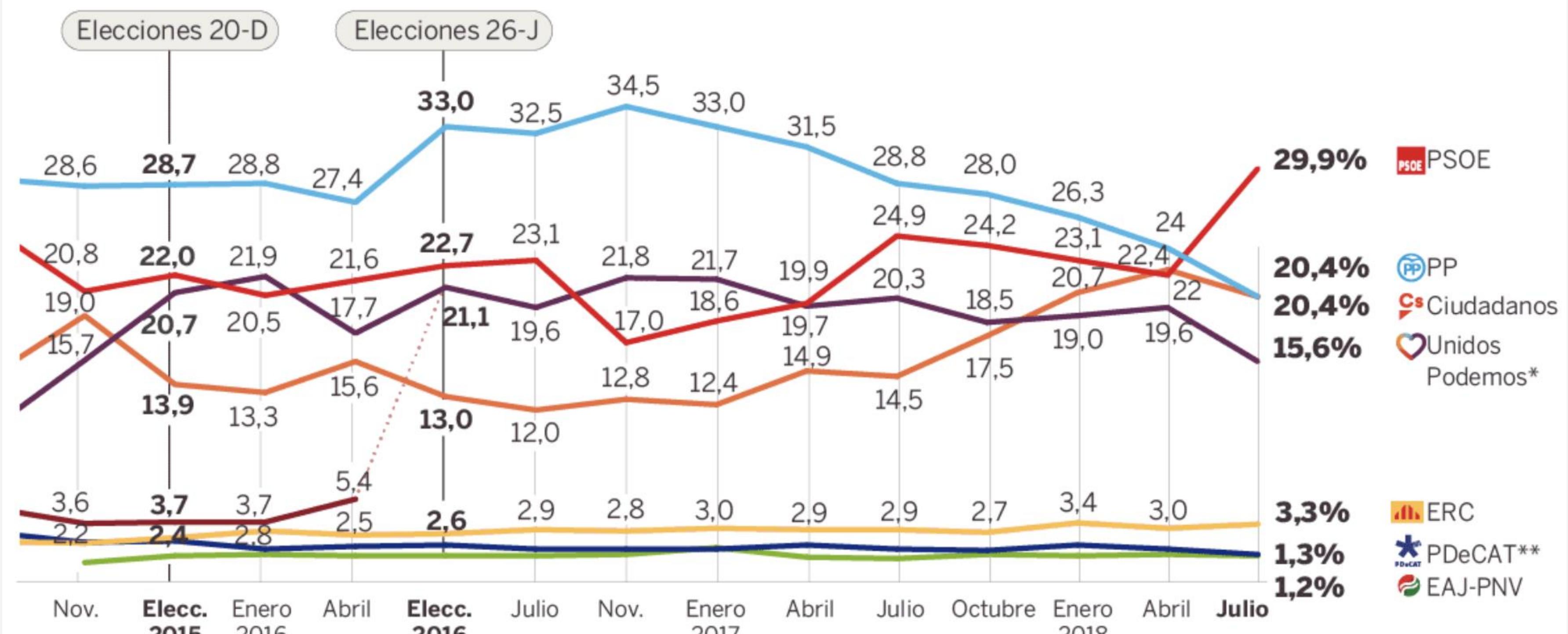


## FICHA TÉCNICA

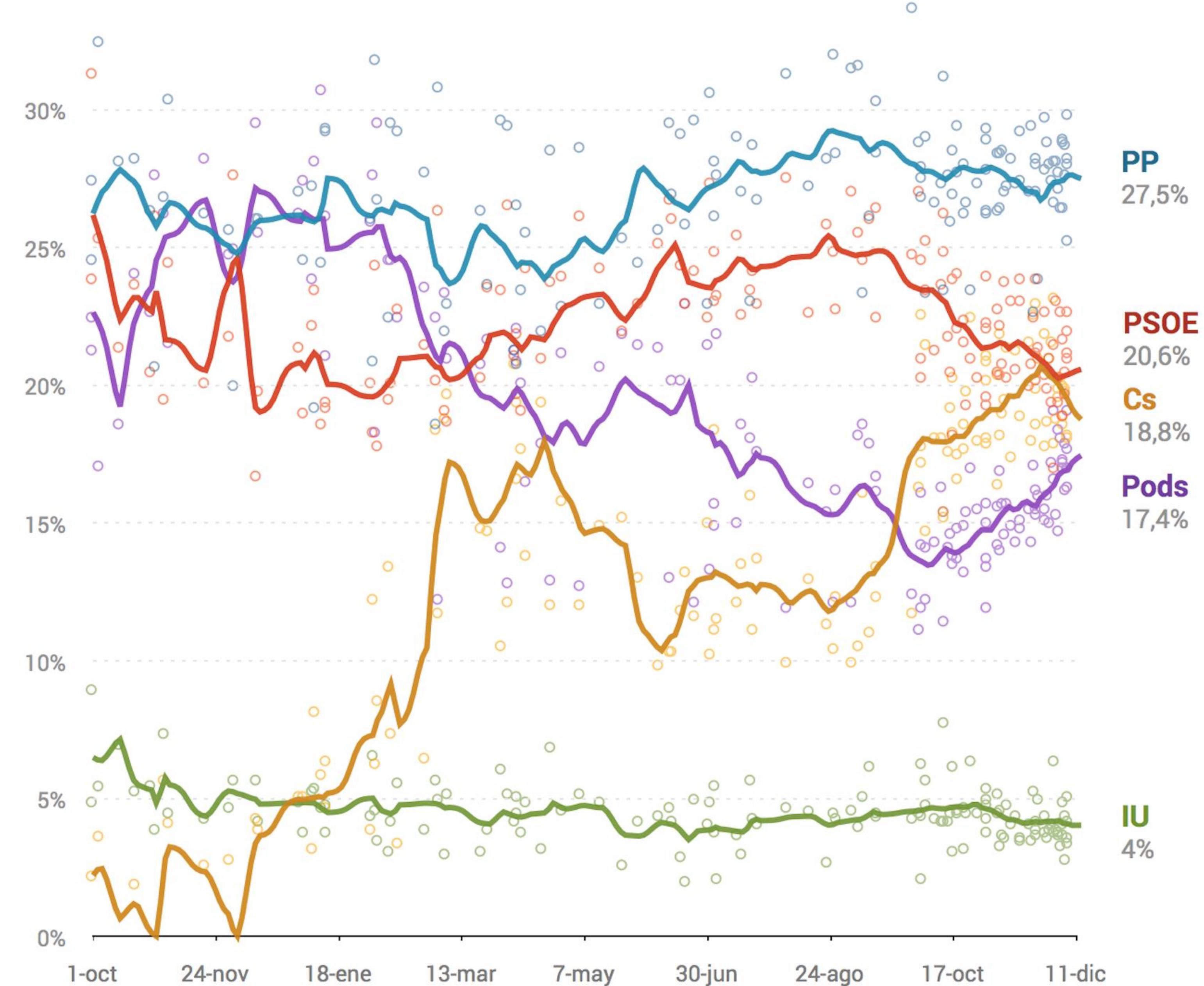
Sondeo efectuado mediante entrevista personal a 2.485 personas mayores de 18 años de ambos性os en 256 municipios de 47 provincias entre el 1 y el 10 de julio. Nivel de confianza: 95,5%. Margen de error: ± 2,0 puntos.

## ESTIMACIÓN DE VOTO

En % sobre voto válido



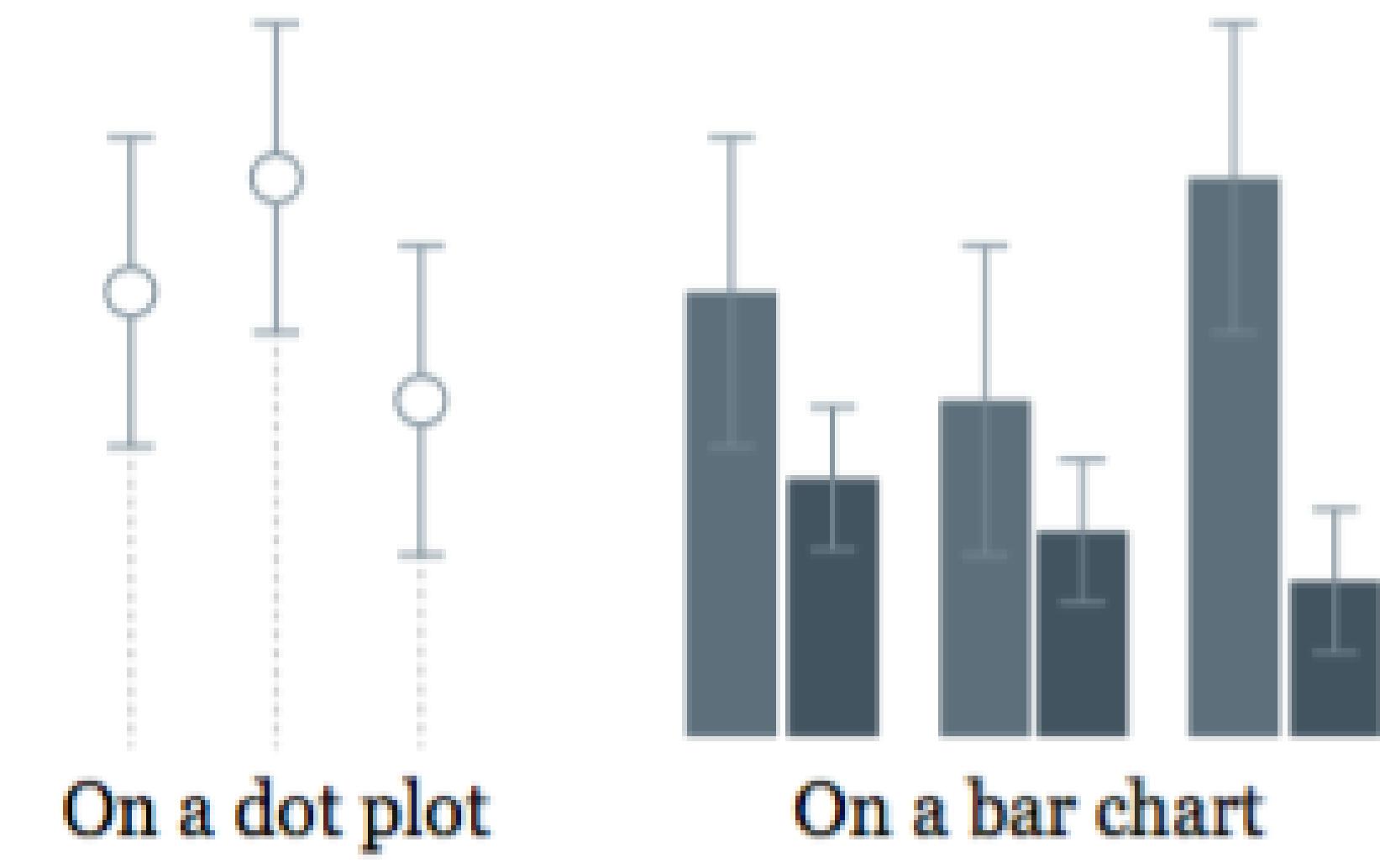
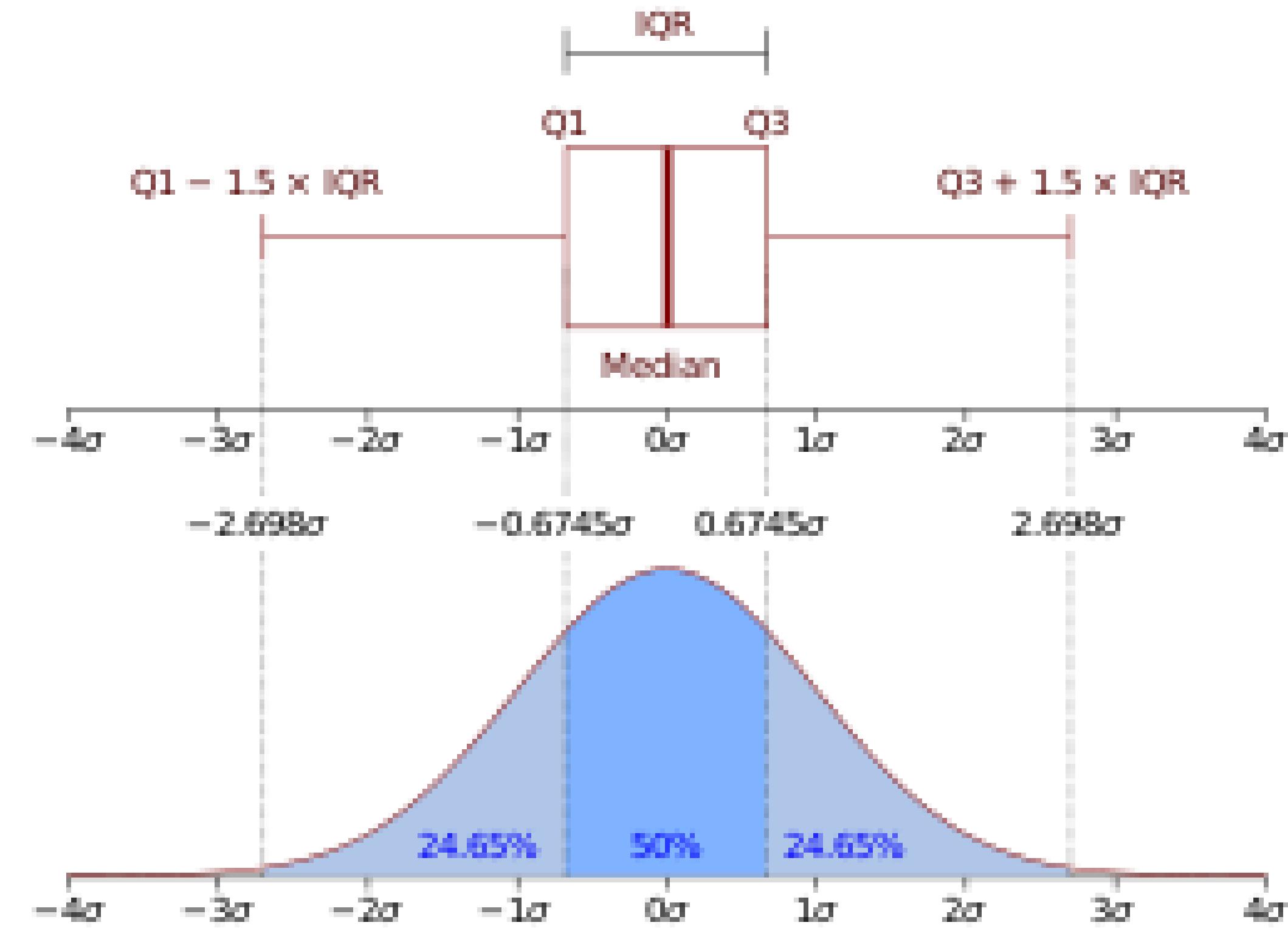
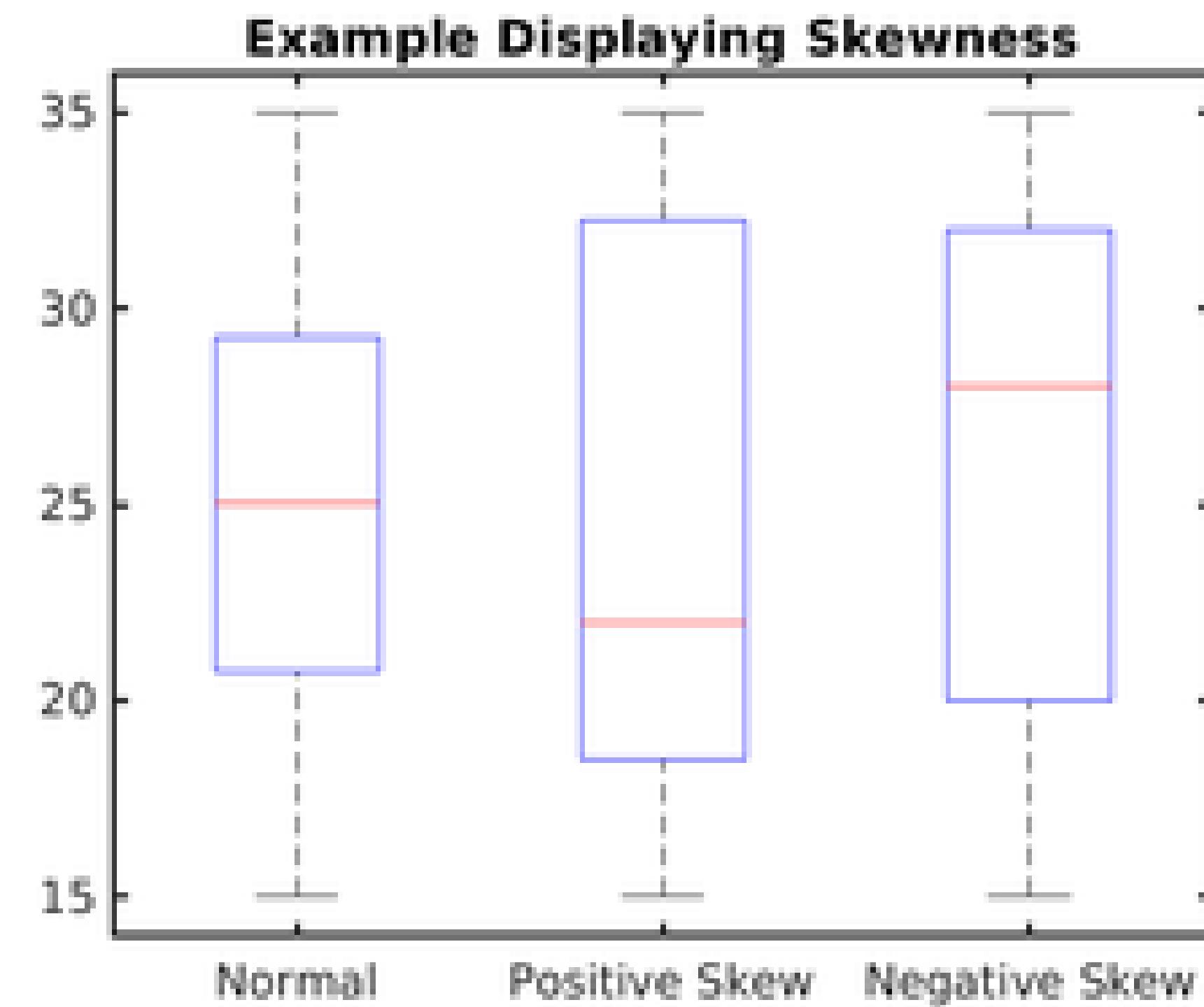
Porcentaje de voto según las encuestas. Las líneas representan un promedio ponderado por fecha, tamaño de muestra y empresa encuestadora.



# Box and whisker plots

Representación visual de Distribución o:

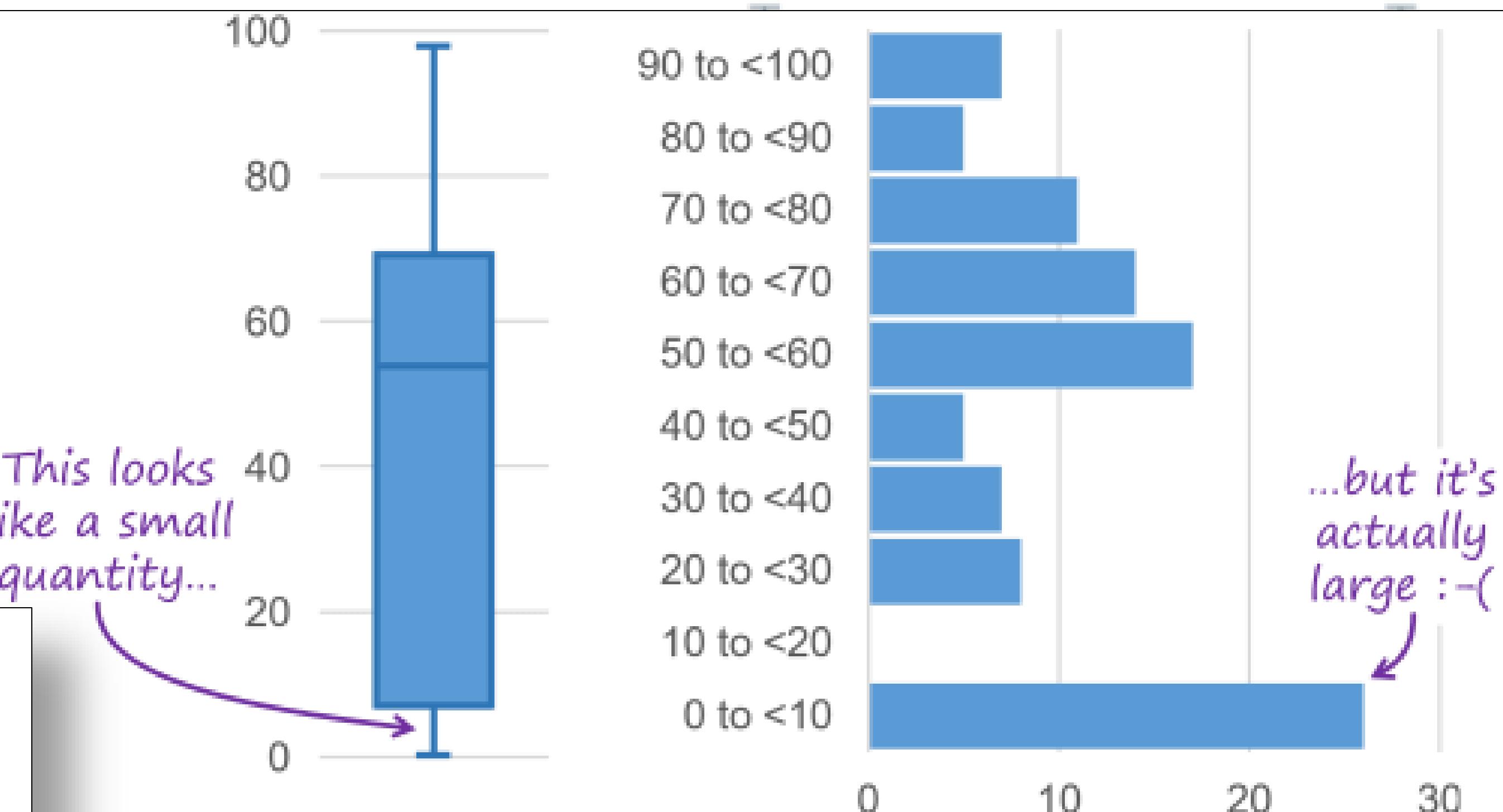
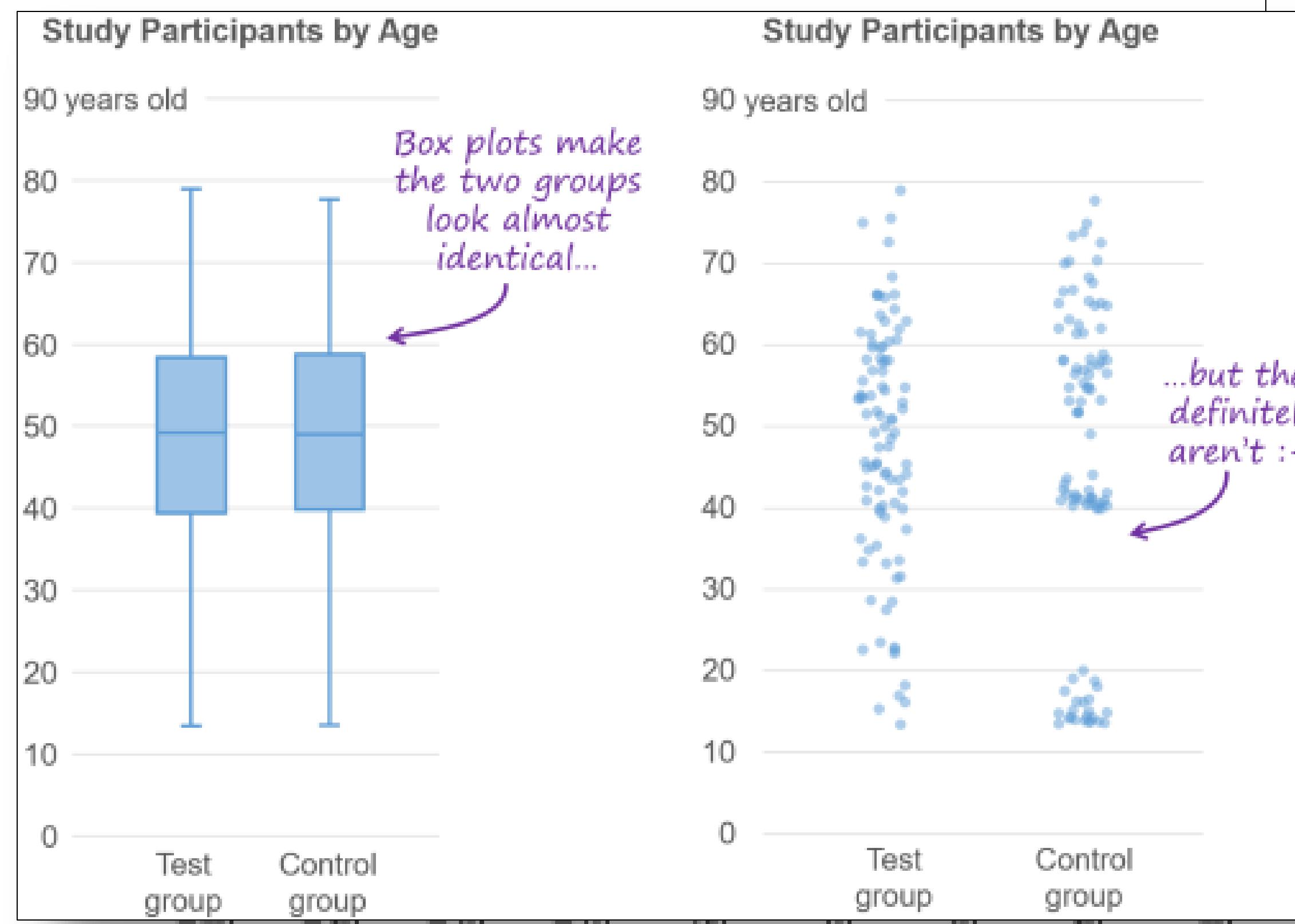
- error
- intervalos de confianza
- Desviacion standard
- Uncertainty
- ...



# Box and whisker plots

Limitaciones:

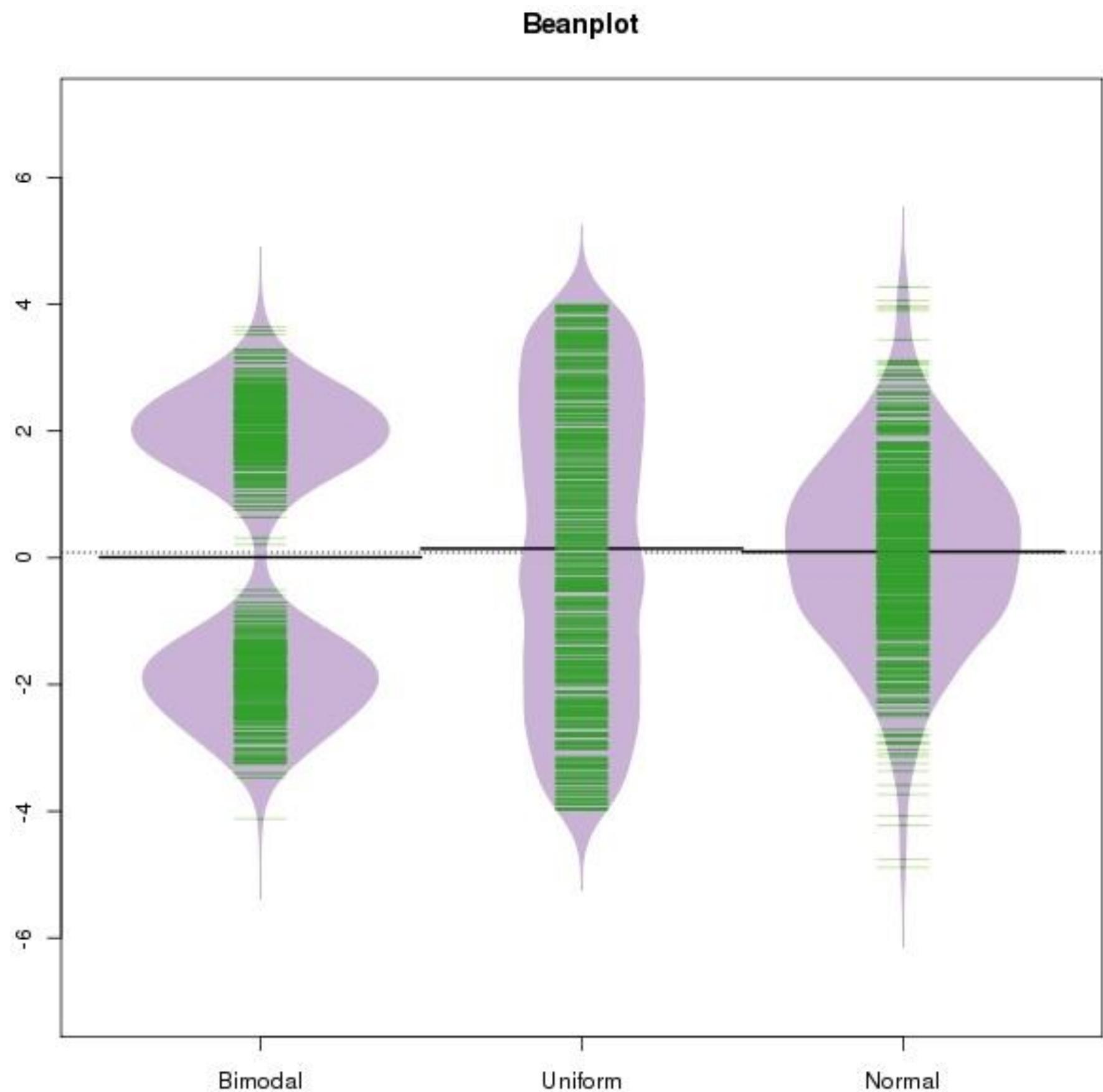
- Box se percibe como unidad
- No muestra toda la distribución
- Asociamos tamaño a cantidad



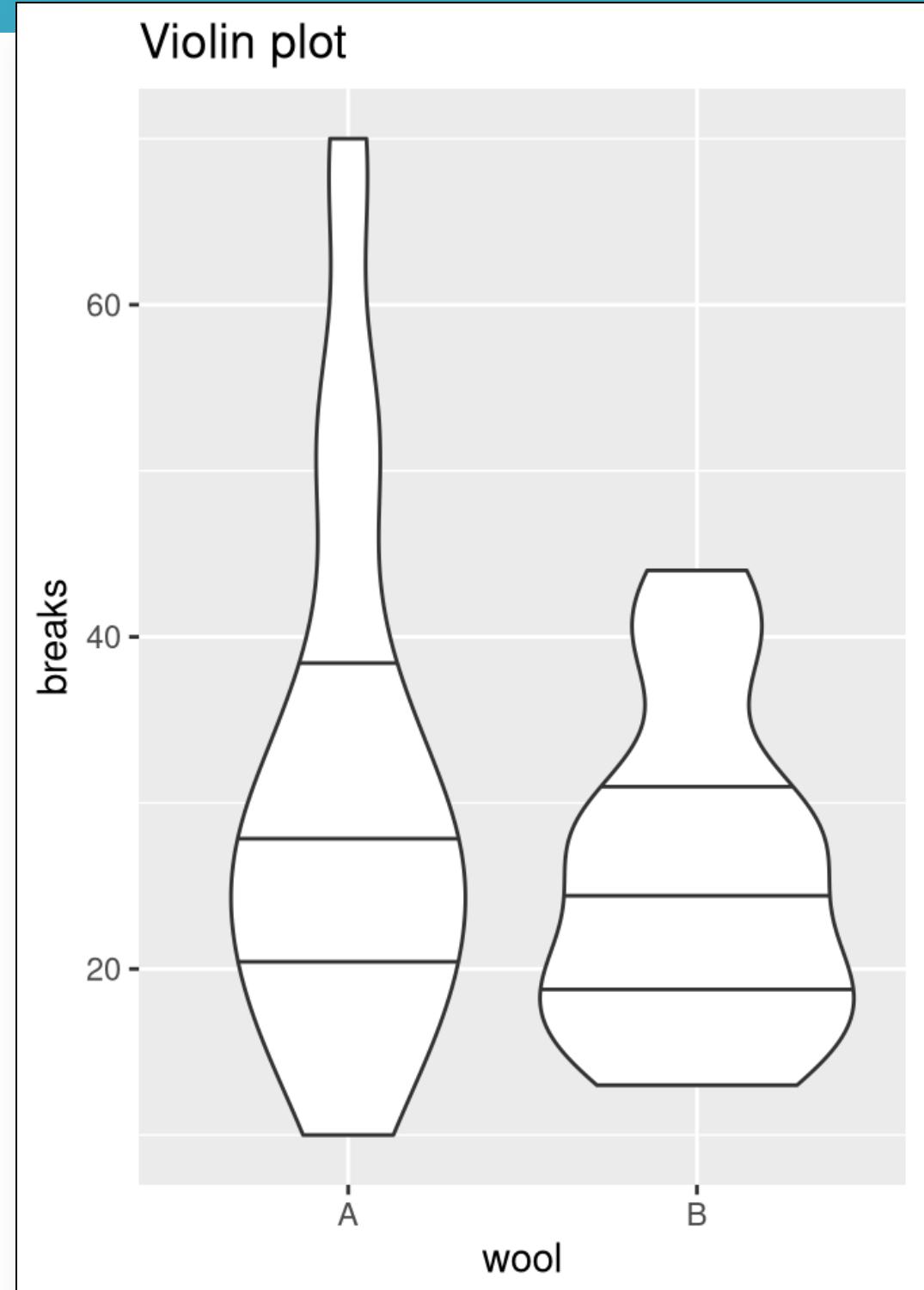
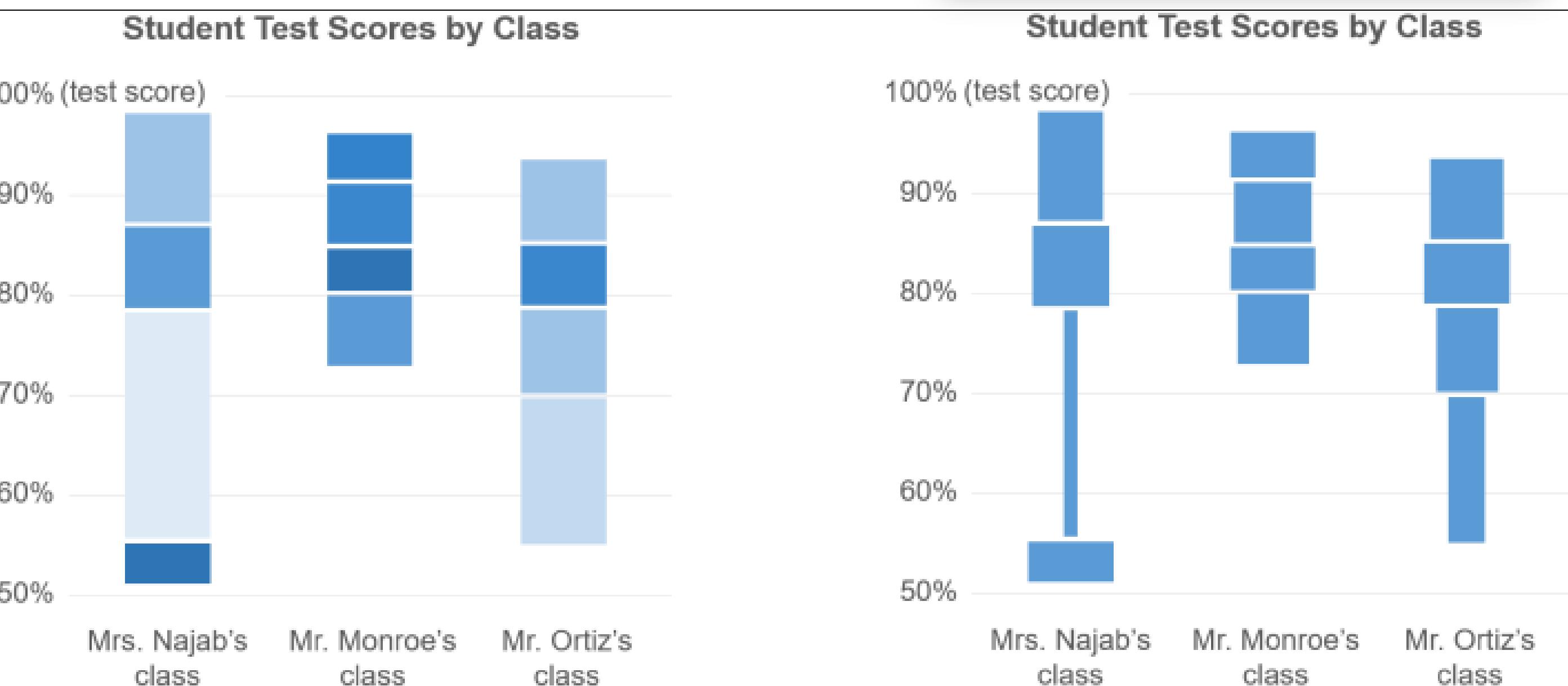
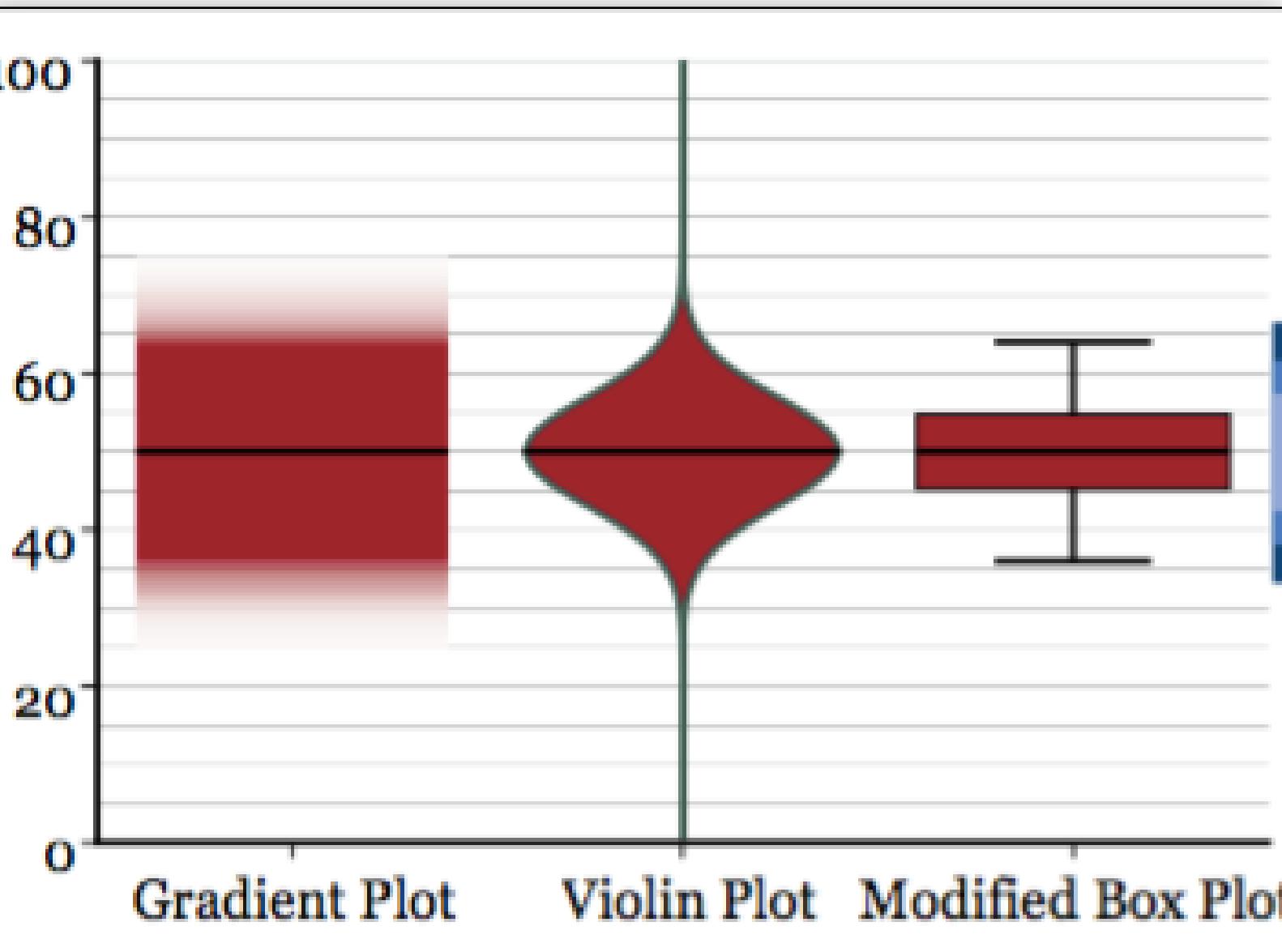
# Box and whisker plots

Alternativas:

- Violin, gradient, Bean plots, ...



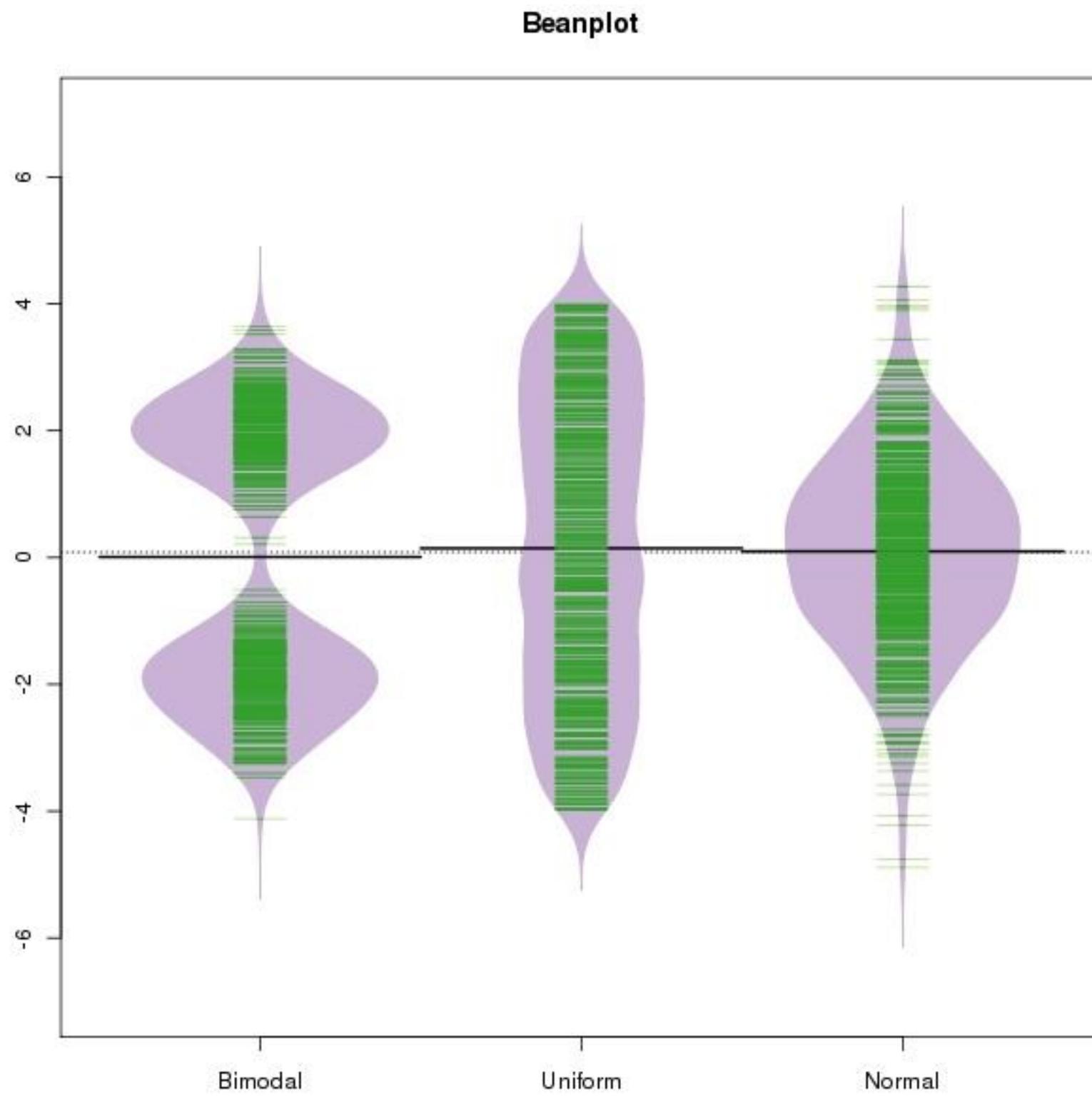
Peter Kampstra, 2008. Beanplot: A Boxplot Alternative for Visual Comparison of Distributions. *Journal of Statistical Software*, 28



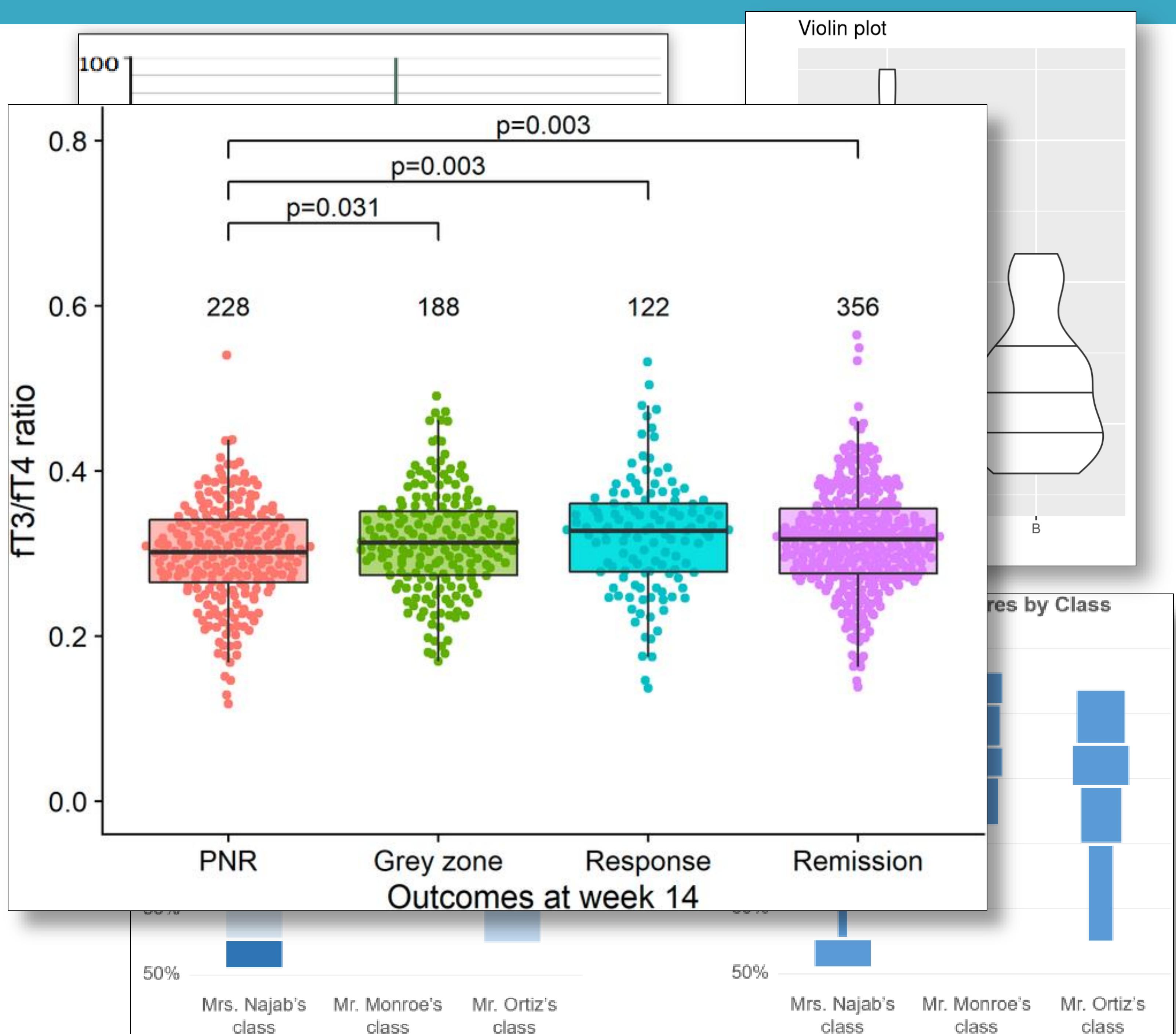
# Box and whisker plots

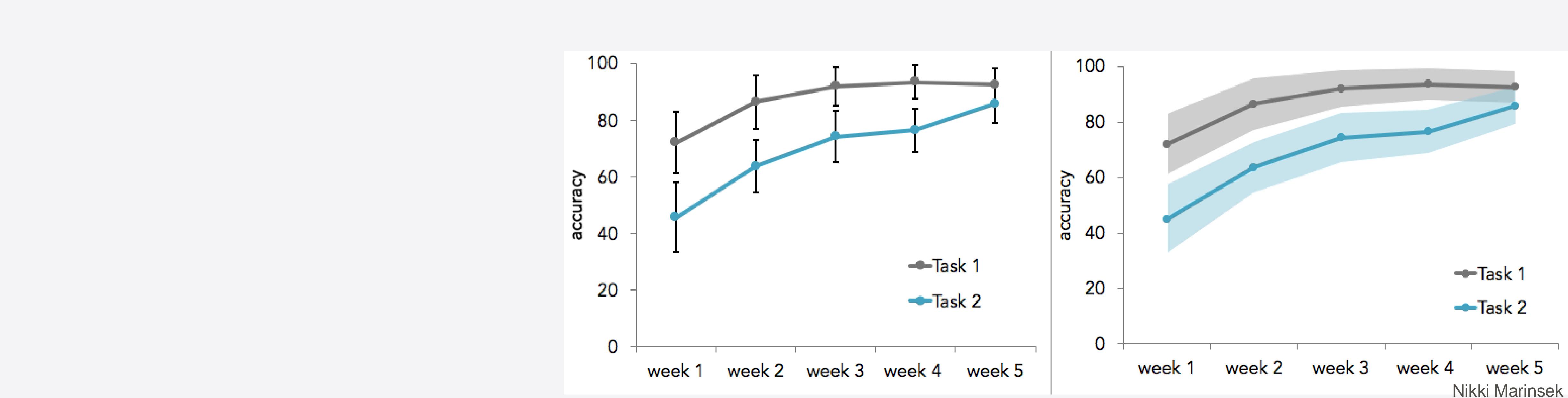
Alternativas:

- Violin, gradient, Bean plots, ...
- Beeswarm



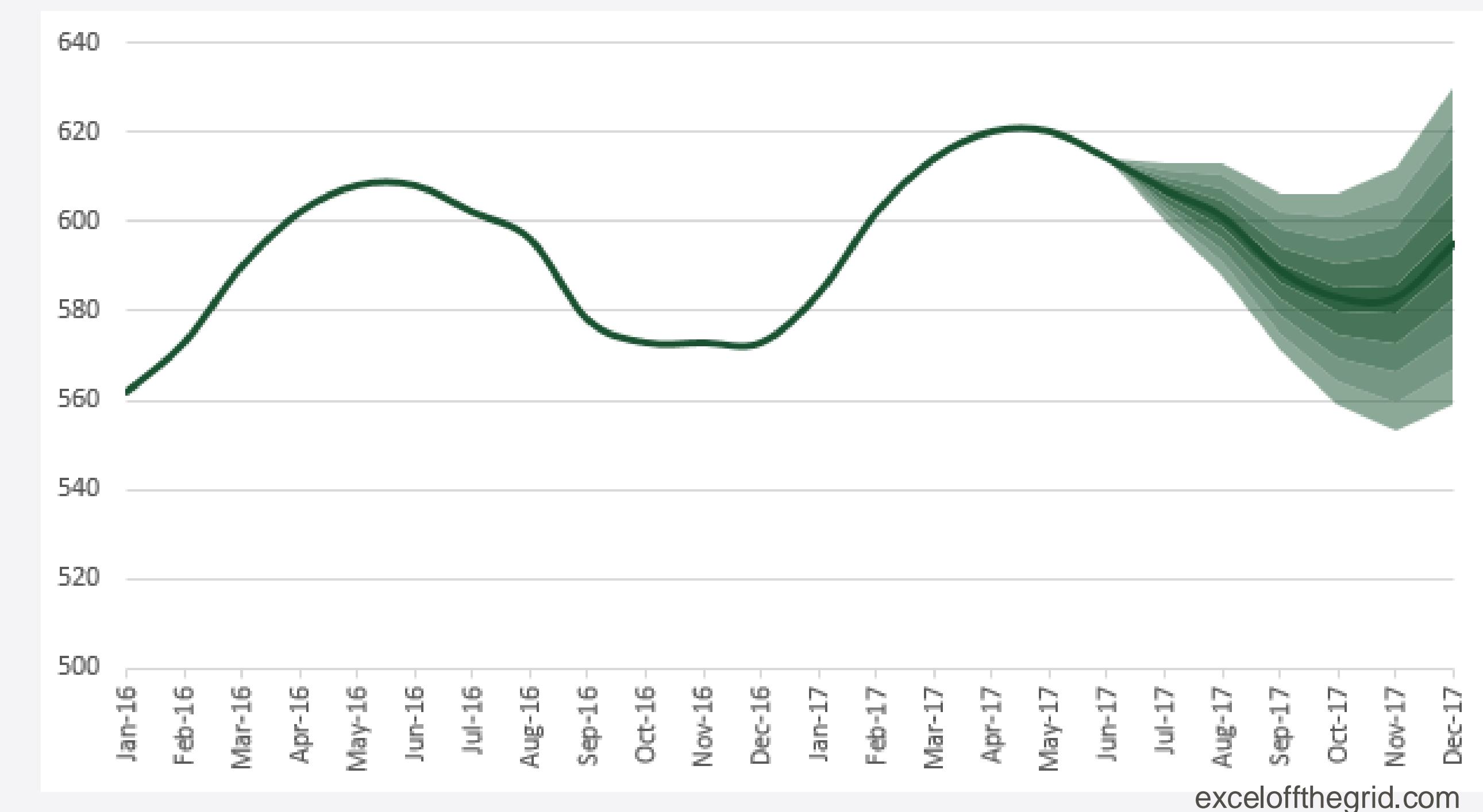
Peter Kampstra, 2008. Beanplot: A Boxplot Alternative for Visual Comparison of Distributions. *Journal of Statistical Software*, 28



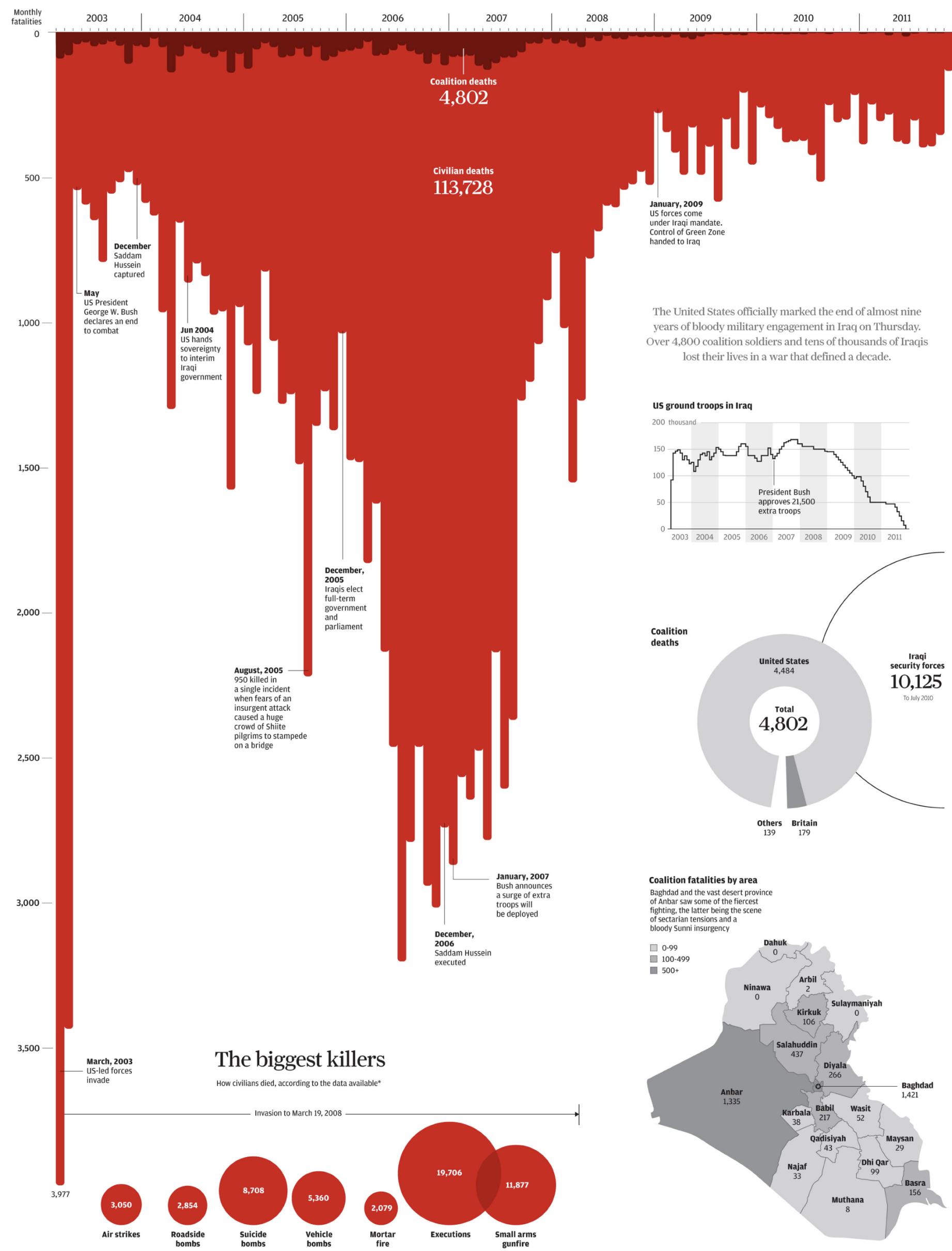


Alternativas a whiskers para  
error/uncertainty en linecharts:

- Error bands
- Fancharts

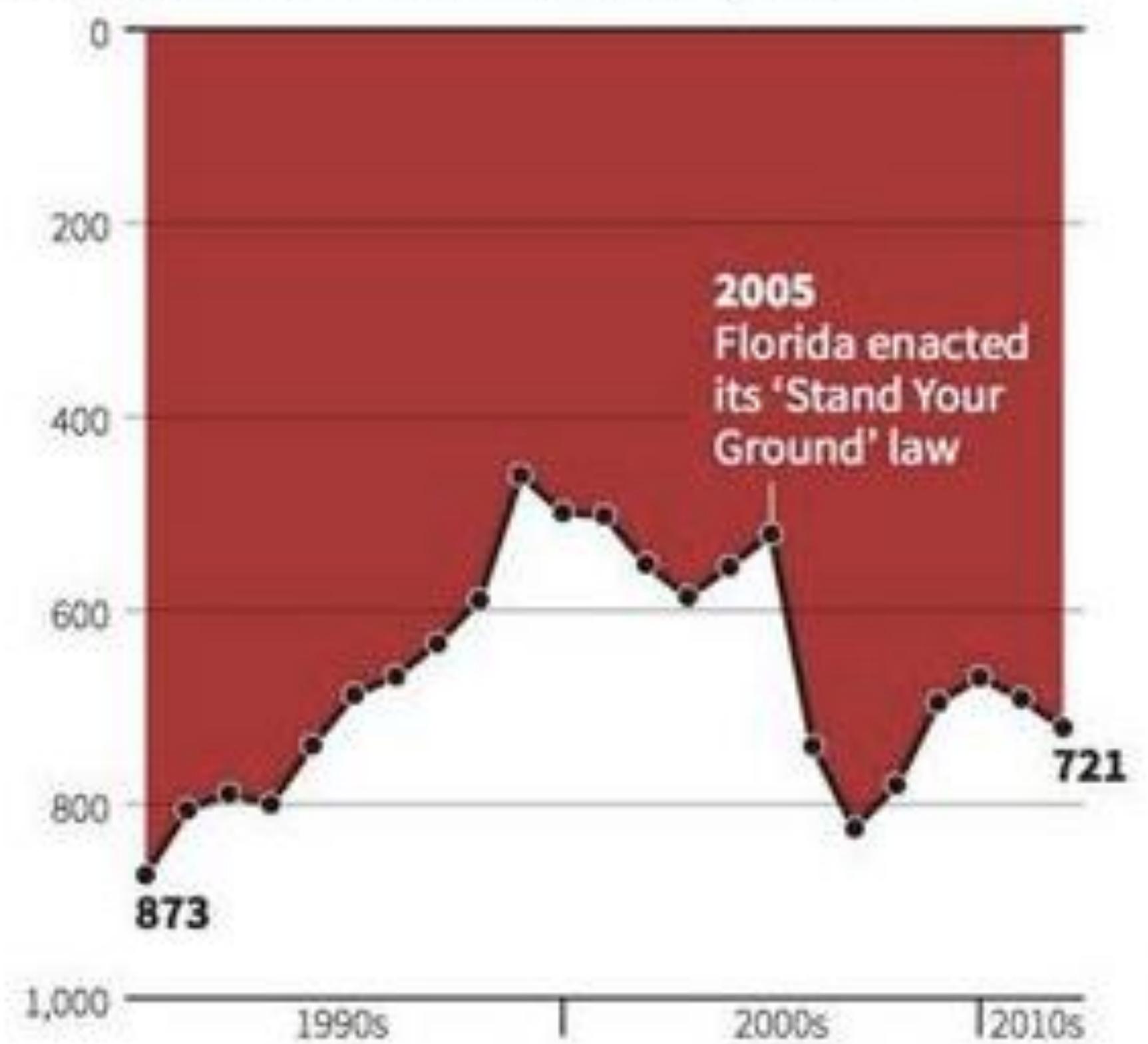


# Iraq's bloody toll



# Gun deaths in Florida

Number of murders committed using firearms



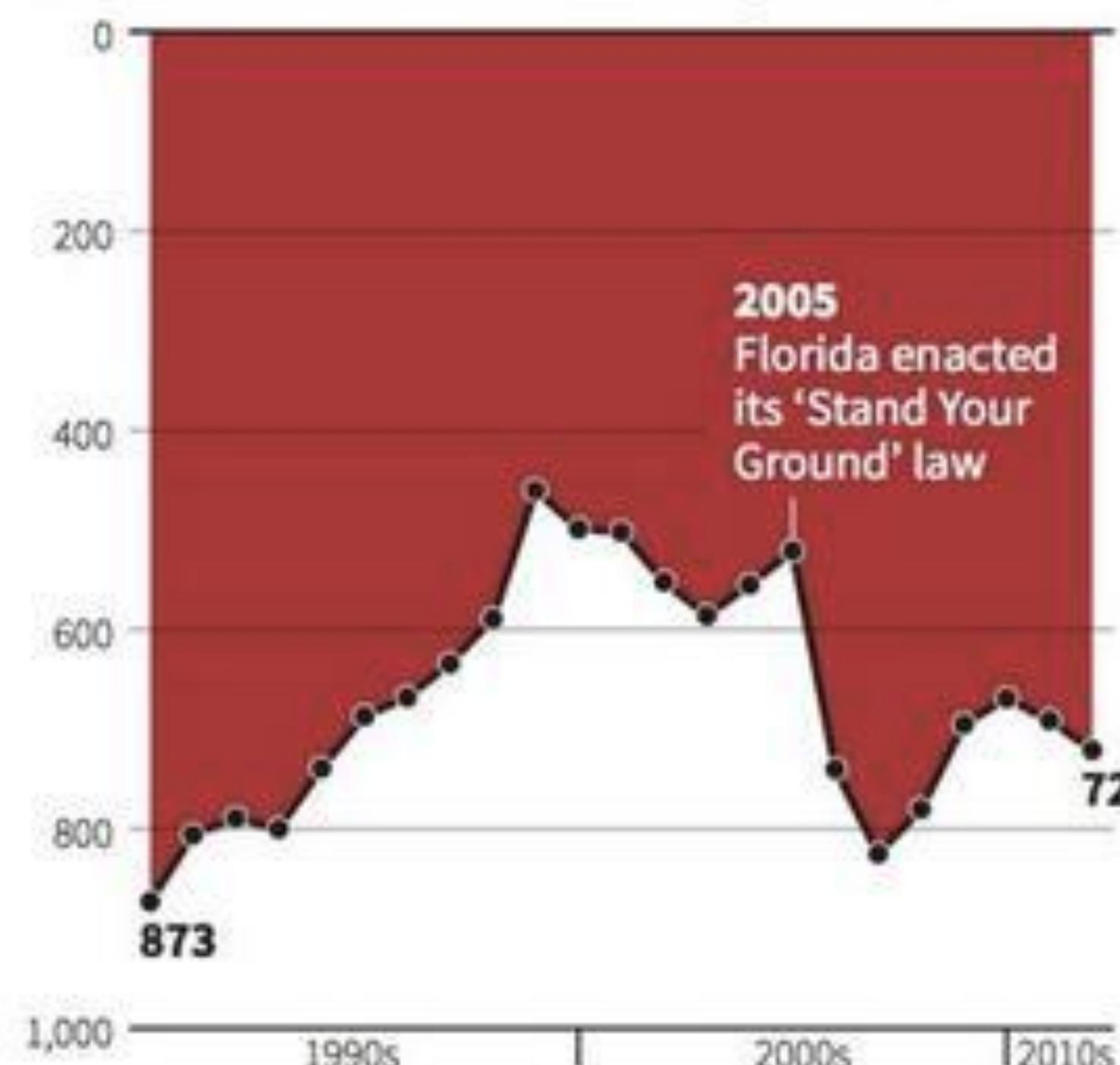
Source: Florida Department of Law Enforcement

C. Chan 16/02/2014

REUTERS

## Gun deaths in Florida

Number of murders committed using firearms

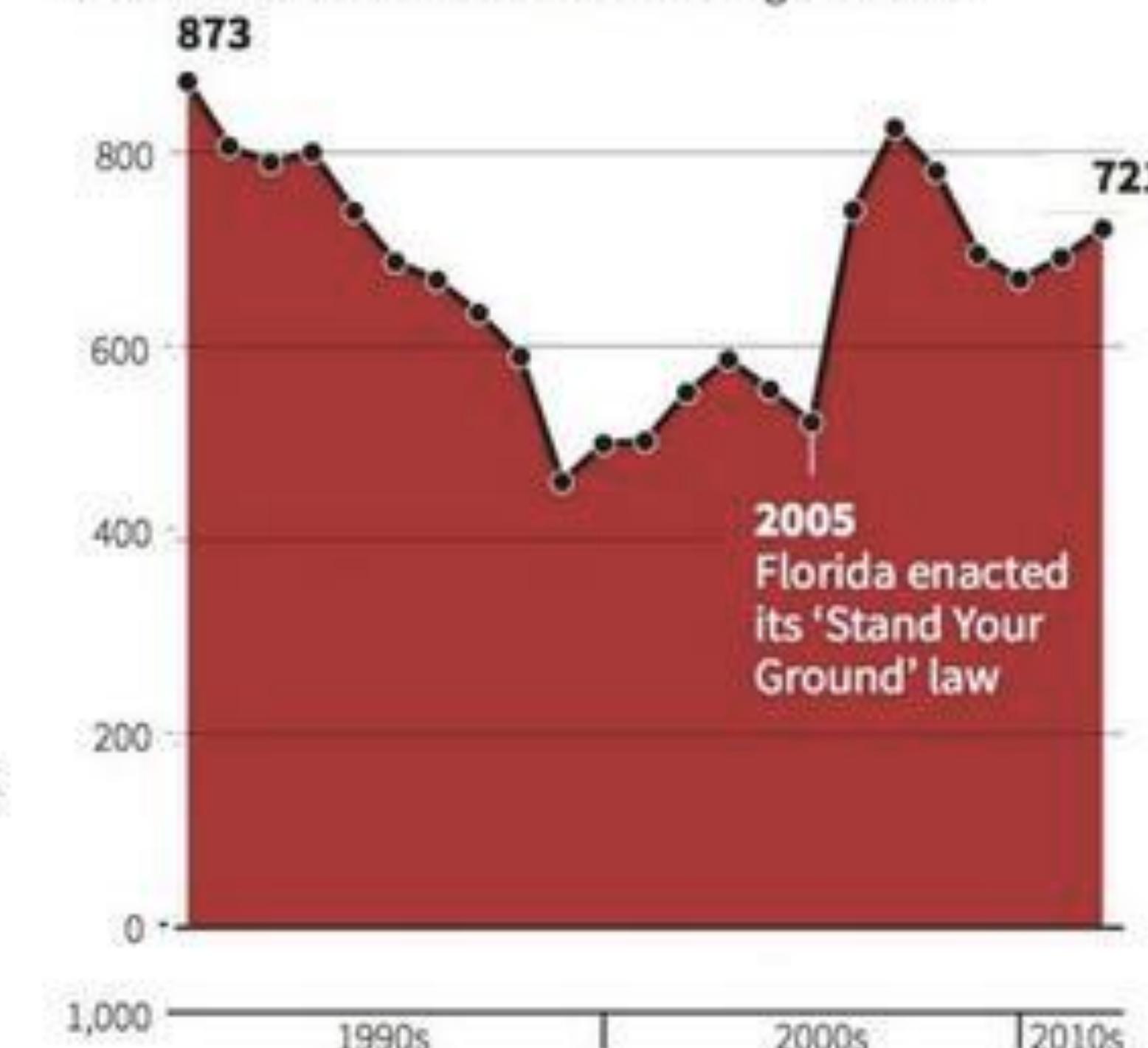


Source: Florida Department of Law Enforcement

C. Chan 16/02/2014

## Gun deaths in Florida

Number of murders committed using firearms



Source: Florida Department of Law Enforcement

C. Chan 16/02/2014

**BEFORE**

**AFTER**

# Referencias

Cairo, A. (2019). How Charts Lie: Getting Smarter about Visual Information. W.W. Norton & Company.

**How Charts Lie by Alberto Cairo (video)**

<https://youtu.be/oX74Nge8Wkw>