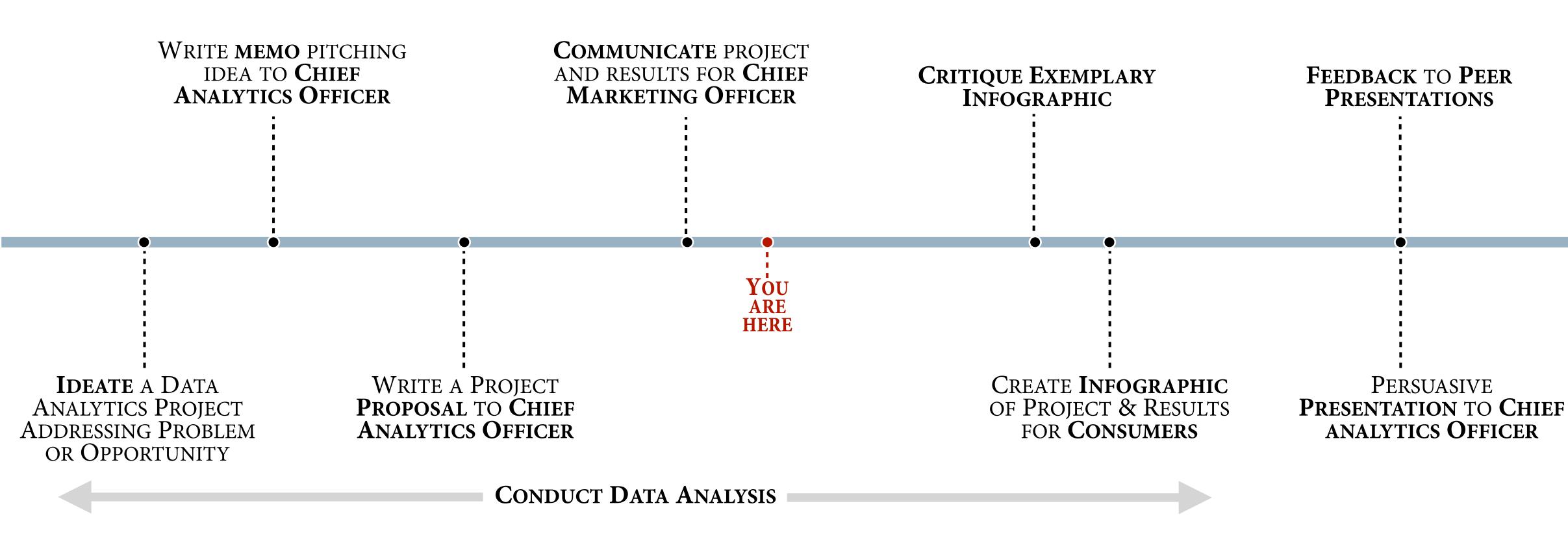
Storytelling With Data

Effective visuals — encoding data graphically: grammar, layers, color

Scott Spencer | Columbia University

Conceptual project timeline



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the grammar of graphics

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the grammar of graphics statistical graphic specifications are expressed in six statements

TRANSFORMATIONS: variable transformations (*e.g.*, *rank*) **SCALES :** scale transformations (*e.g.*, *log*) **COORDINATES** : a coordinate system (*e.g.*, *cartesian*, *polar*)

GUIDES : one or more guides (*axes*, *legends*, *etc*.)



Wilkinson, Leland

- **DATA** : a set of data operations that create variables from datasets
- **ELEMENTS**: graphs (e.g., points, lines) and their aesthetic attributes (e.g., color, opacity, shape, size, orientation)



the grammar of graphics | ggplot2 is the grammar of graphics implemented in R

load grammar of graphics library(ggplot2)

p <-

functions for data ink

DATA **TRANSFORMATIONS**

ELEMENTS

SCALES & GUIDES

COORDINATES

ggplot(data = mappin

<pre>geom_<type>(<</type></pre>
<pre>scale_<mappin< pre=""></mappin<></pre>
<pre>coord_<type>(</type></pre>
<pre>facet_<type>(</type></pre>
< > +

GUIDES # functions for

> labs(<...>) + theme(<...> = annotate(<...>) < . . . >



Wickham, Hadley

for non-data ink	<pre>element_blank()</pre>
	<pre>element_blank() element_line(<> = <</pre>
+	<pre>element_rect(<> = <</pre>
= <	element_text(<> = <
>) +	

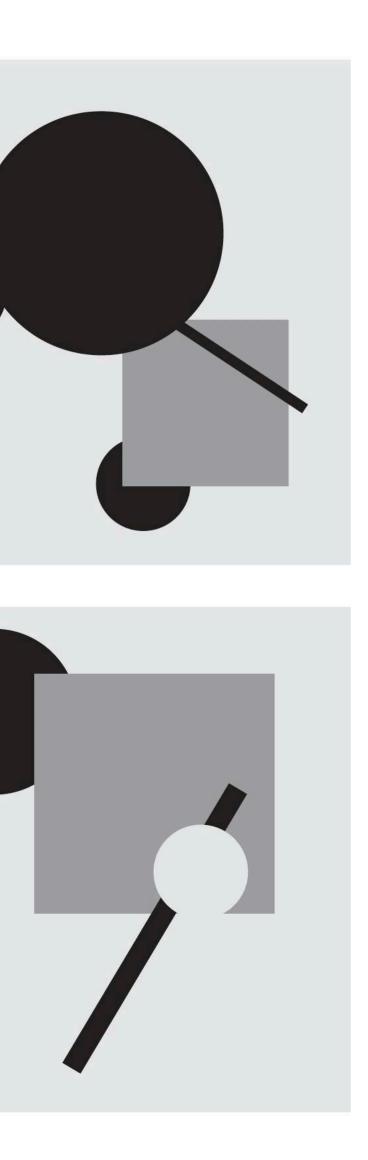
thinking about graphics as layers

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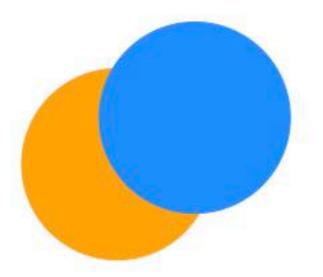
graphics as layers when one form or shape overlaps another, we see an illusion of near and far.

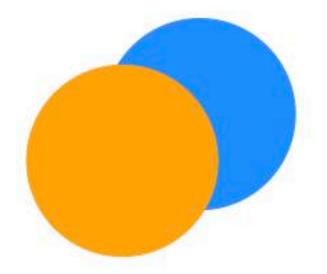


Samara, Timothy



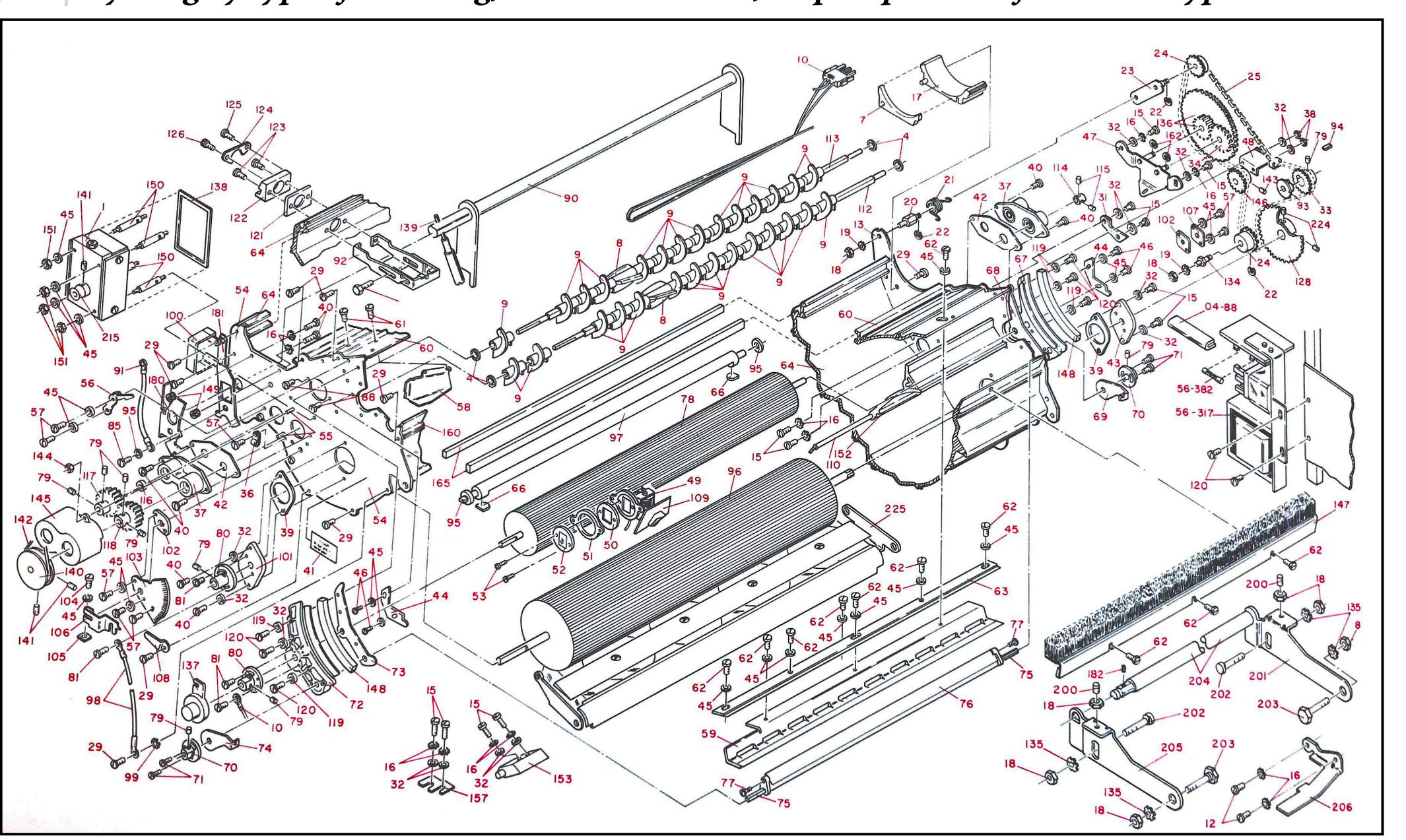
graphics as layers order of elements determines position towards reader and when overlapping, occlude.





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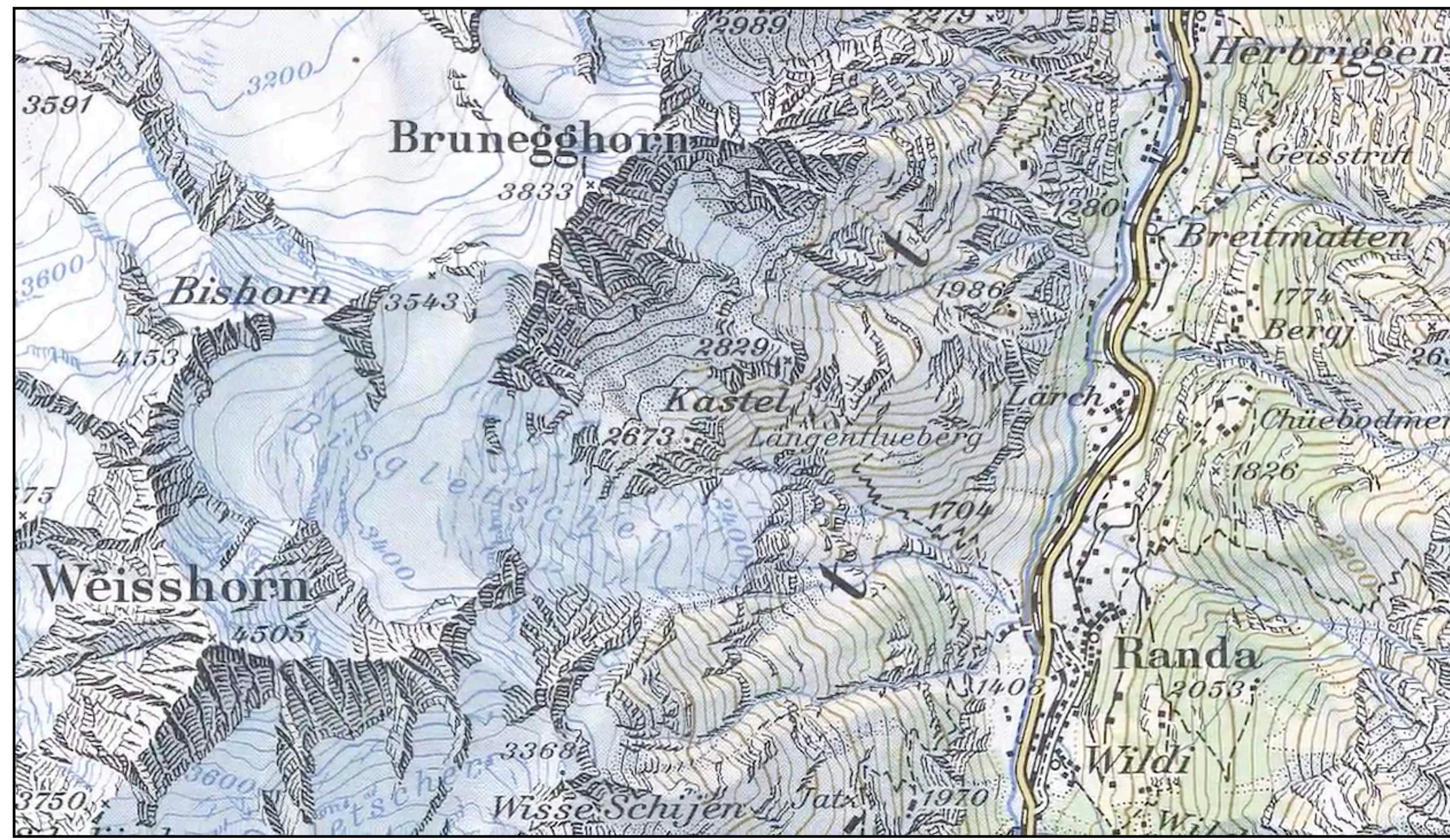
graphics as layers | layering by type of encoding, color in this case, helps separate information types.

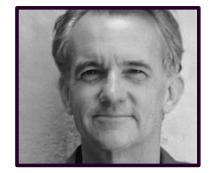




Tufte, Edward

graphics as layers | layering by type of encoding helps separate information types. Maps tend to be exemplary.





Tufte, Edward





graphics as layers | in this example, observed data are separately layered "behind" scale of residuals.

A. LINEAR MODEL

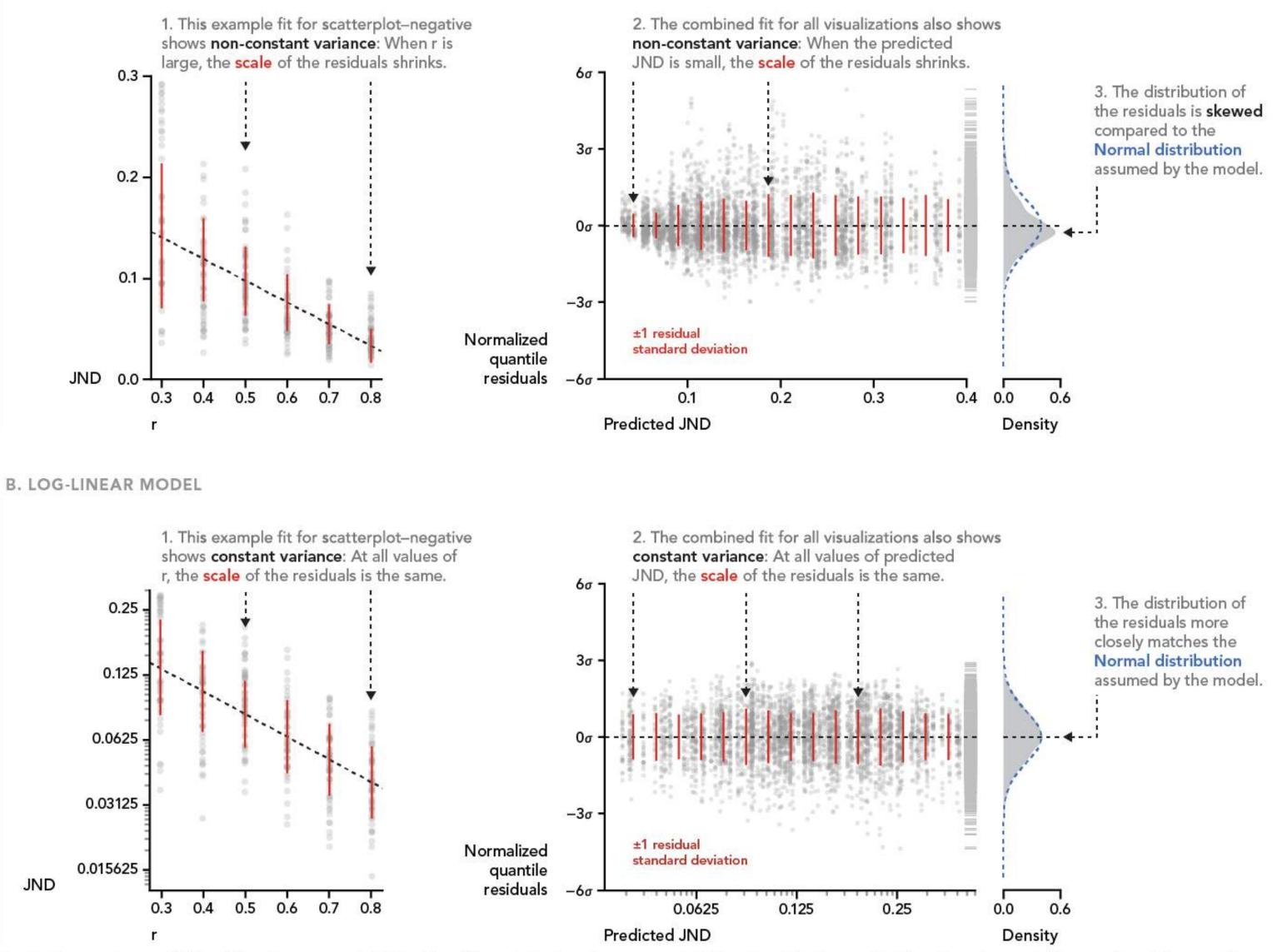
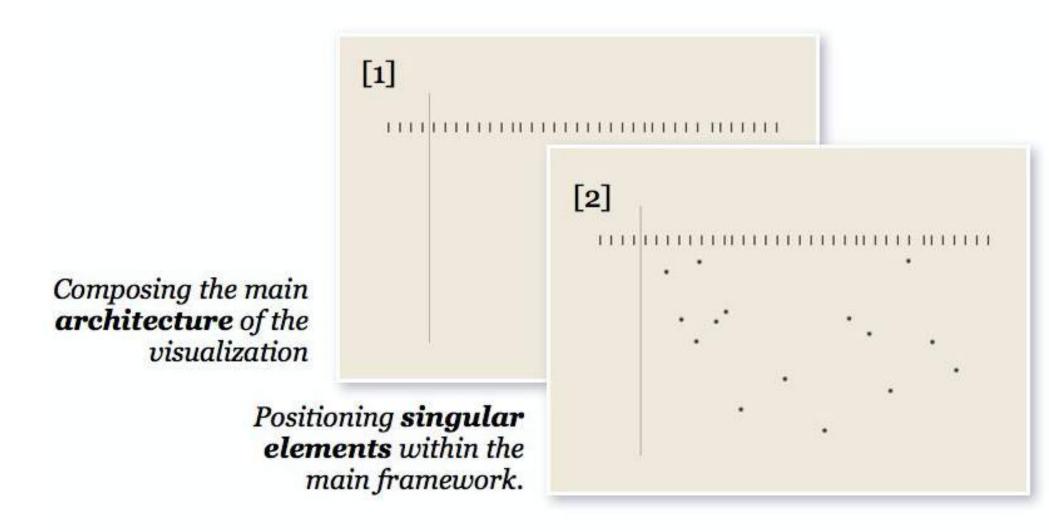


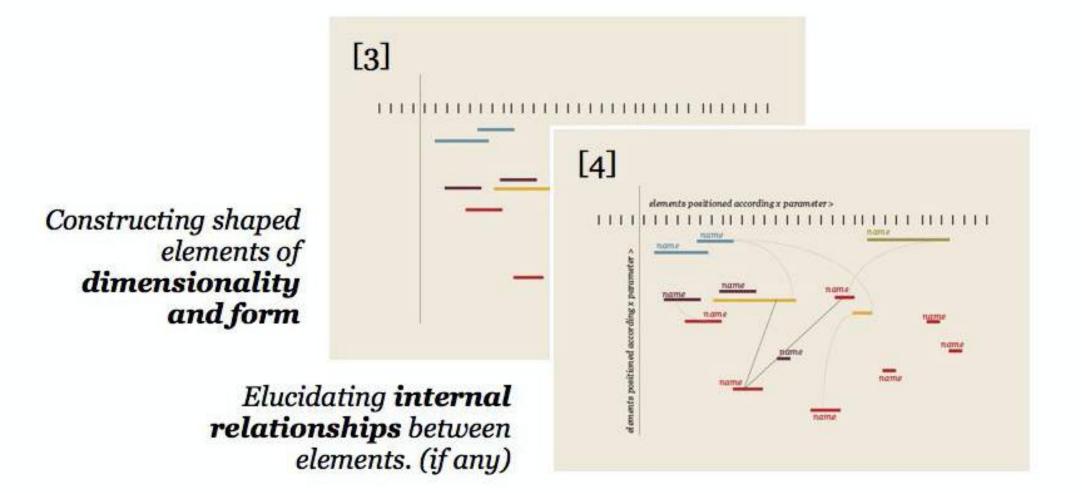
Fig. 3 Comparison of fits of the linear model (Section 3) and the log-linear model (Section 4). Example fits of each model to scatterplot-negative are shown in A.1 and B.1. Plots of normalized residuals for all visualization × direction pairs are shown in A.2 and B.2. Density plots of normalized residuals with comparison to the standard normal distribution are shown in A.3 and B.3.

Kay, Matthew



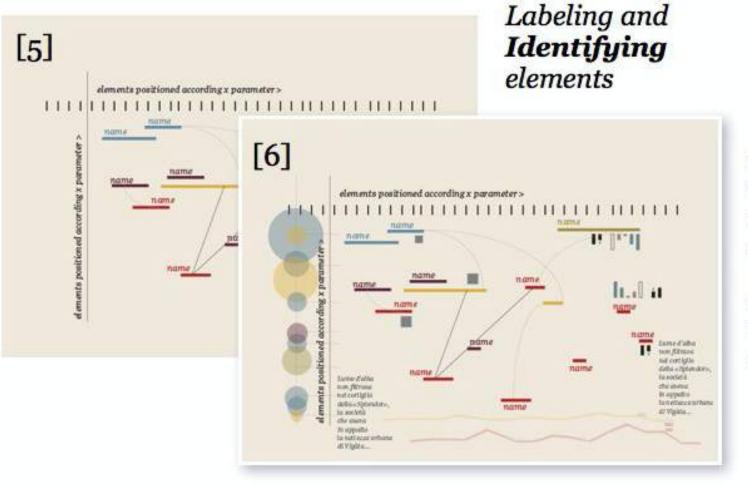
graphics as layers | layering can create hierarchy and clarity in graphics narratives





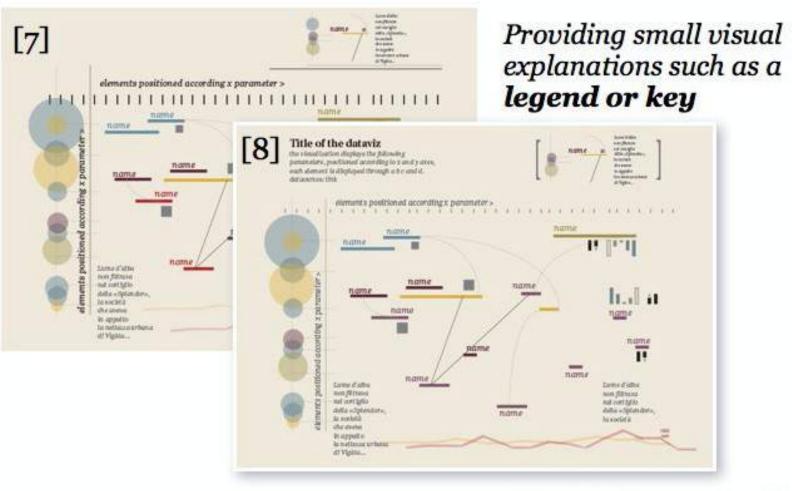


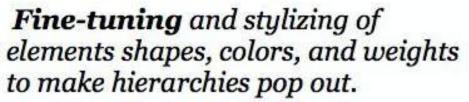
Lupi, Giorgia

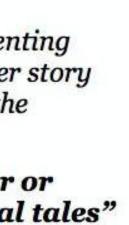


Supplementing the greater story through the addition

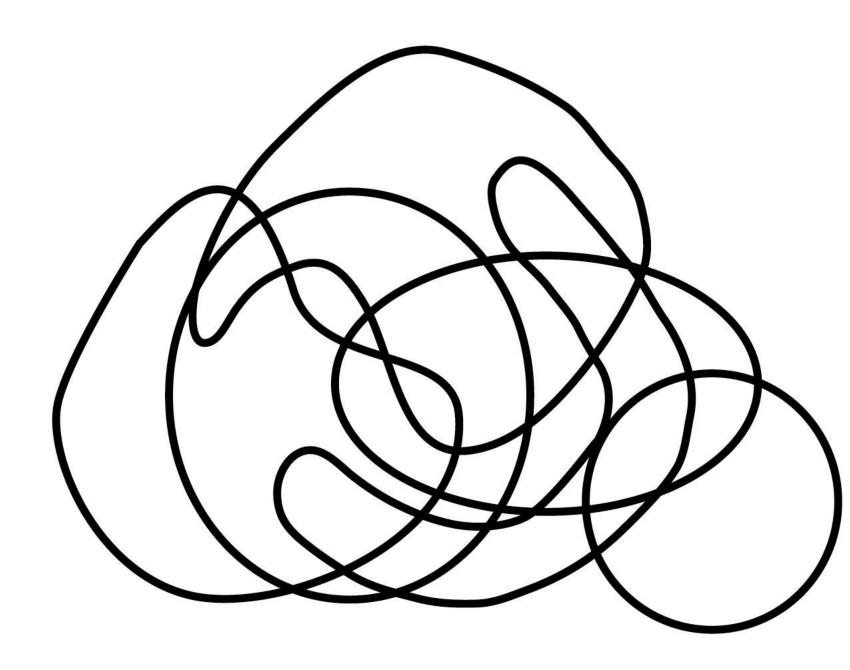
of "minor or tangental tales" elements

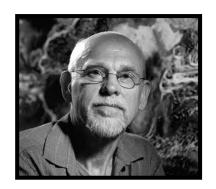




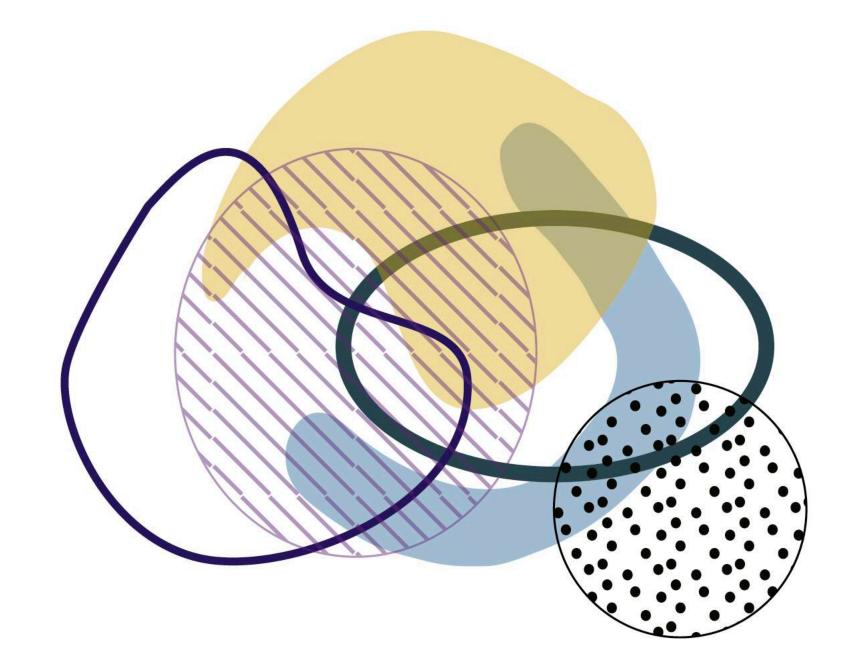


graphics as layers in this Euler diagram, color and texture help to distinguish layers of information



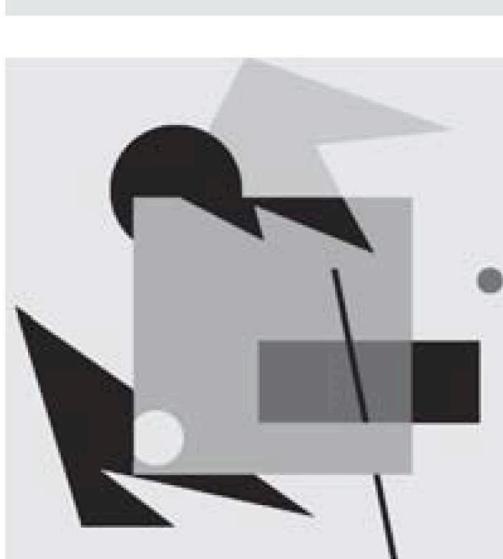


Ware, Colin



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Samara, Timothy

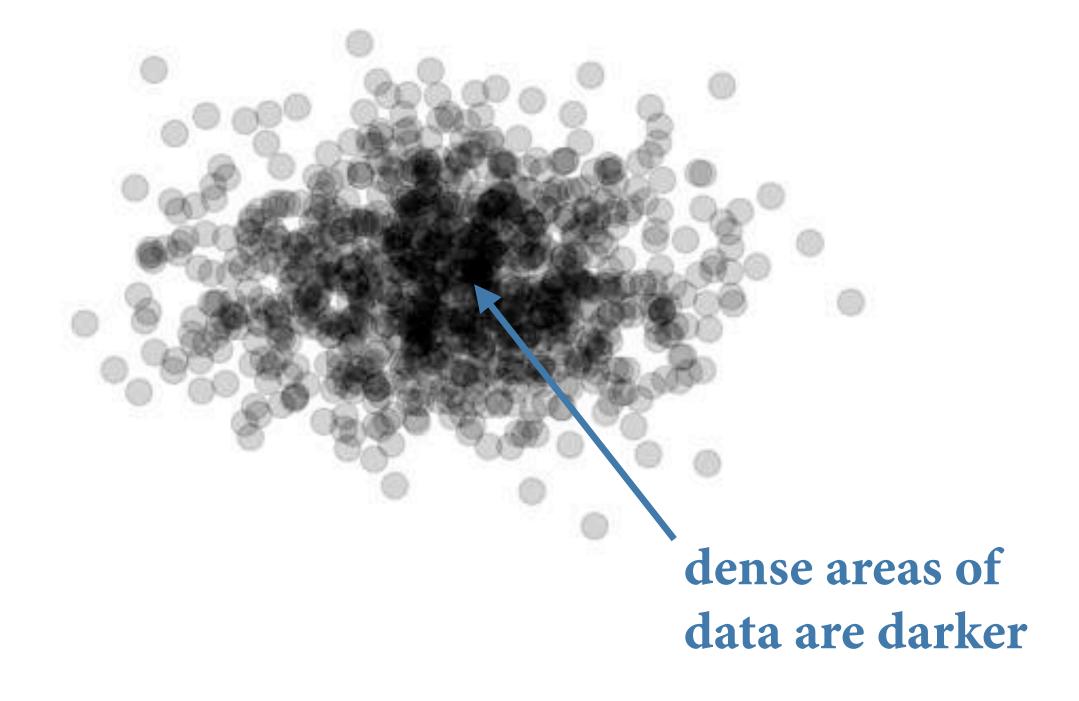
graphics as layers | transparency can enhance, or create conflicts with, the illusion of spatial arrangement.





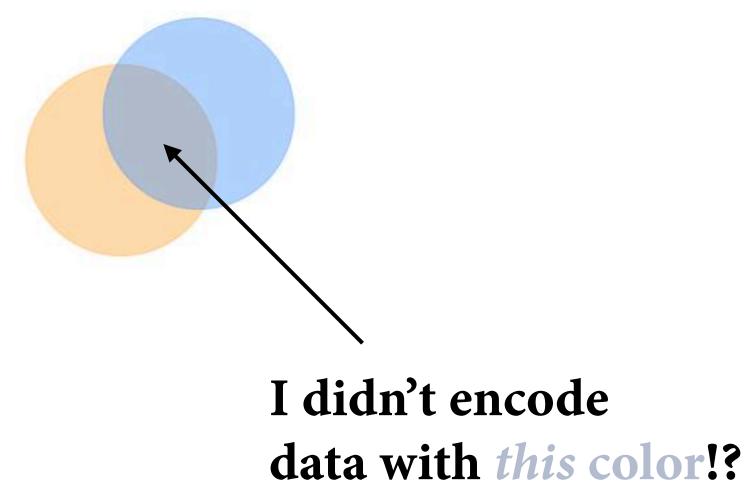
```
x <- rnorm(1000)
y <- rnorm(1000)
```

```
ggplot() +
  theme_void() +
  scale_x_continuous(limits = c(-5, 5)) +
  scale_y_continuous(limits = c(-5, 5)) +
  geom_point(aes(x = x, y = y)),
             size = 4, color = "black",
             alpha = 0.2
```



graphics as layers | layered data encoded in color, if overlapping, is affected by transparency!

```
ggplot() +
  theme_void() +
  scale_x_continuous(limits = c(-5, 5)) +
  scale_y_continuous(limits = c(-5, 5)) +
  geom_point(aes(x = 0, y = 0))
             size = 50, color = "orange",
             alpha = 0.4) +
  geom_point(aes(x = 1, y = 1)),
             size = 50, color = "dodgerblue",
             alpha = 0.4
```



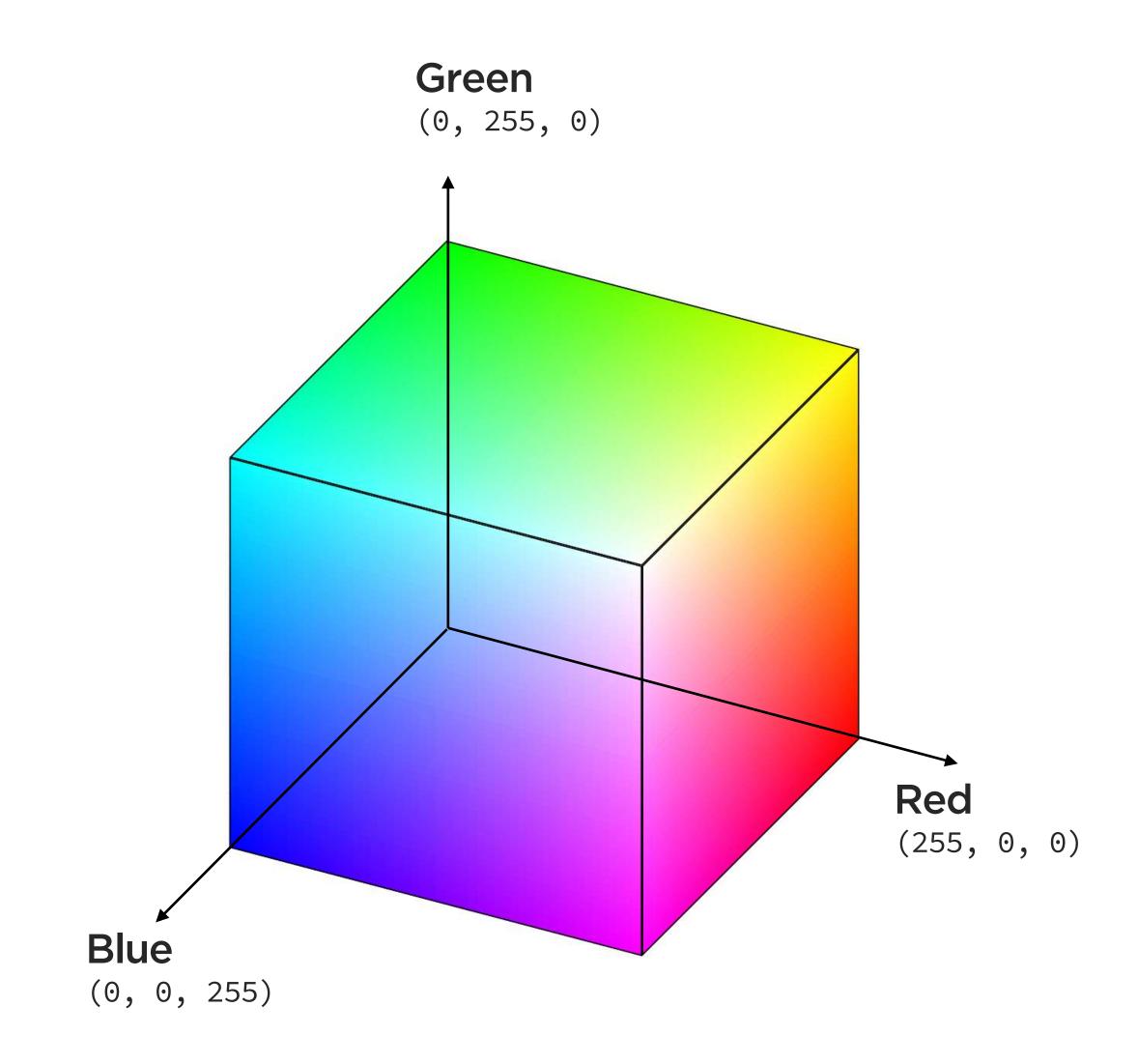


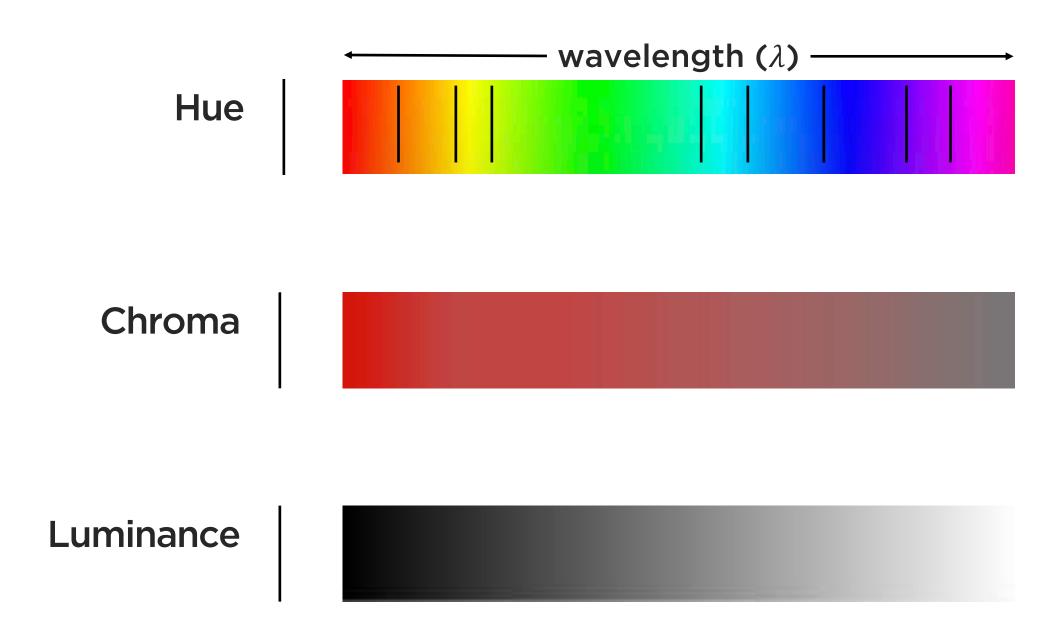
encoding data as color

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color encode data using color spaces, which are mathematical models

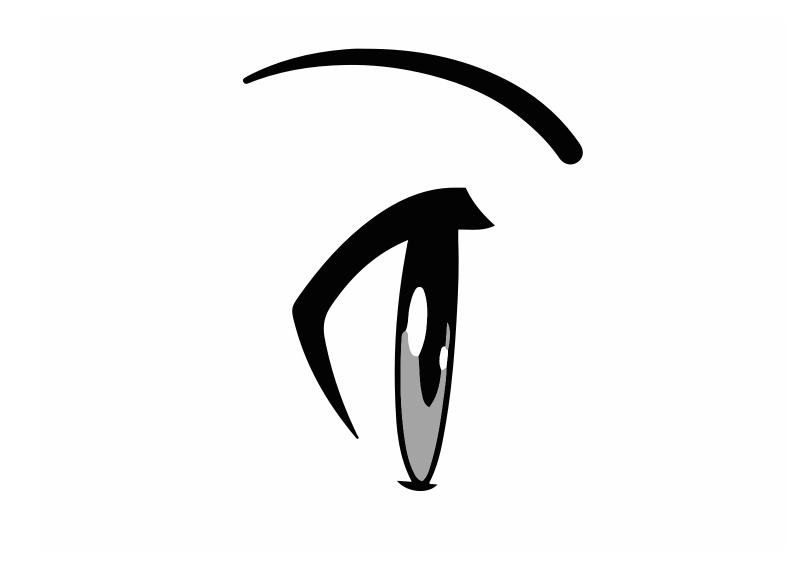


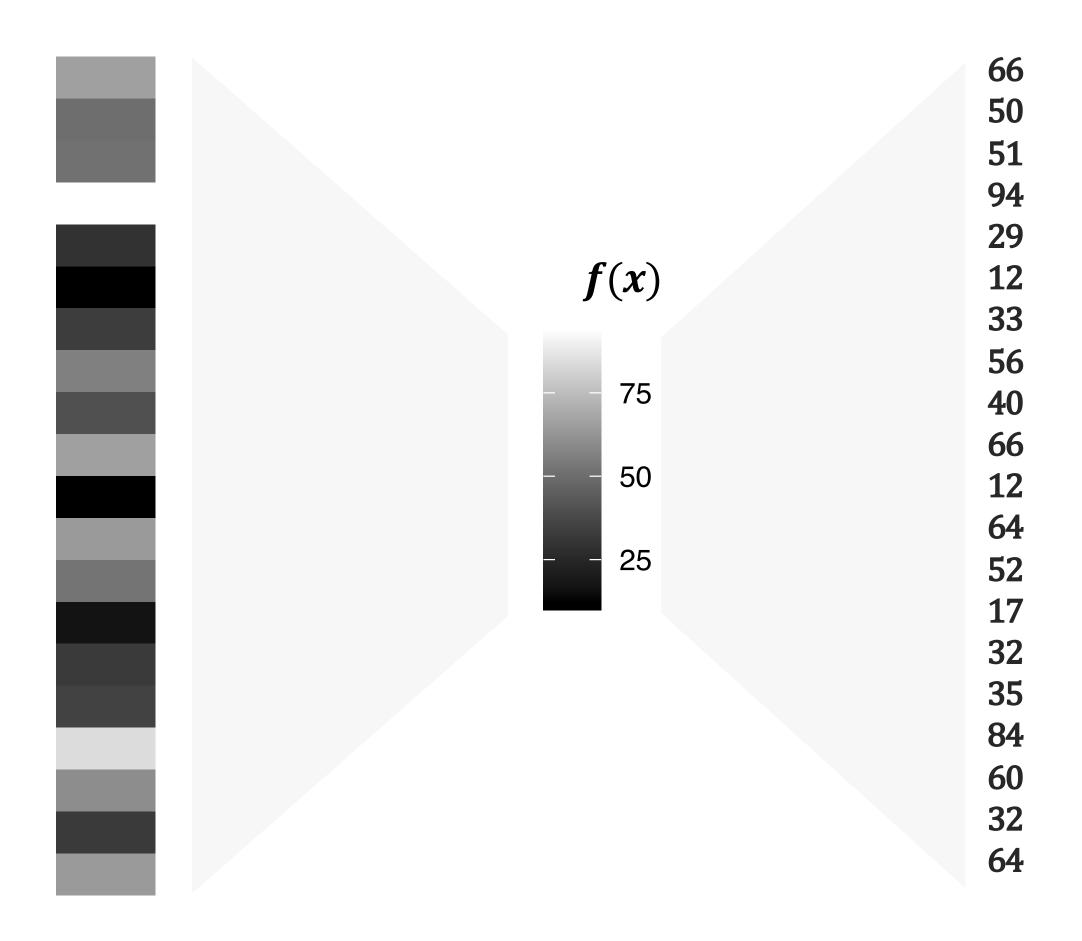


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color how can we map data to light, whether using its hue, chroma, or luminance?





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color | *perceived brightness is nonlinear function of luminance*

LUMINANCE : the *measured* amount of light coming from some region of space.

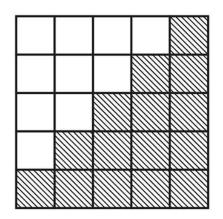
BRIGHTNESS: the *perceived* amount of light coming from that region of space.



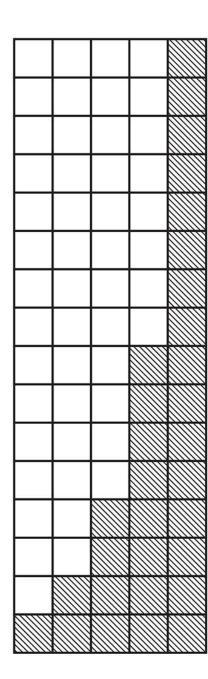
Ware, Colin

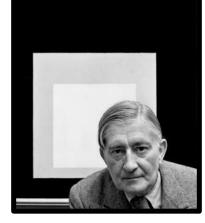


color visual perception of an arithmetical progression depends on a physical geometric progression



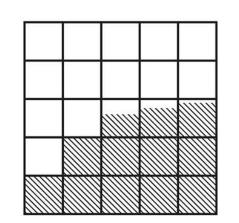
THIS PHYSICAL FACT





THIS PHYSICAL FACT

Albers, Josef

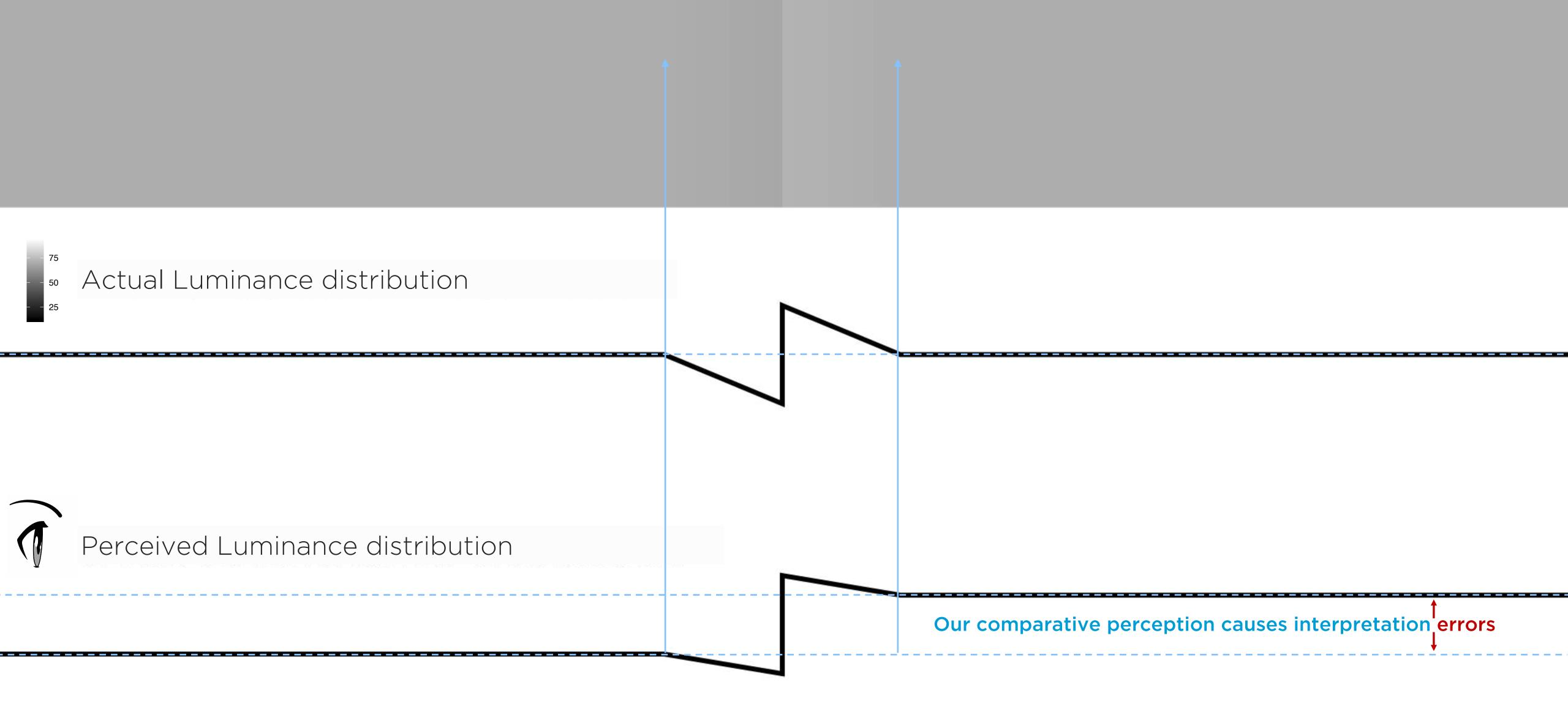


REDUCES TO THIS PSYCHOLOGICAL EFFECT

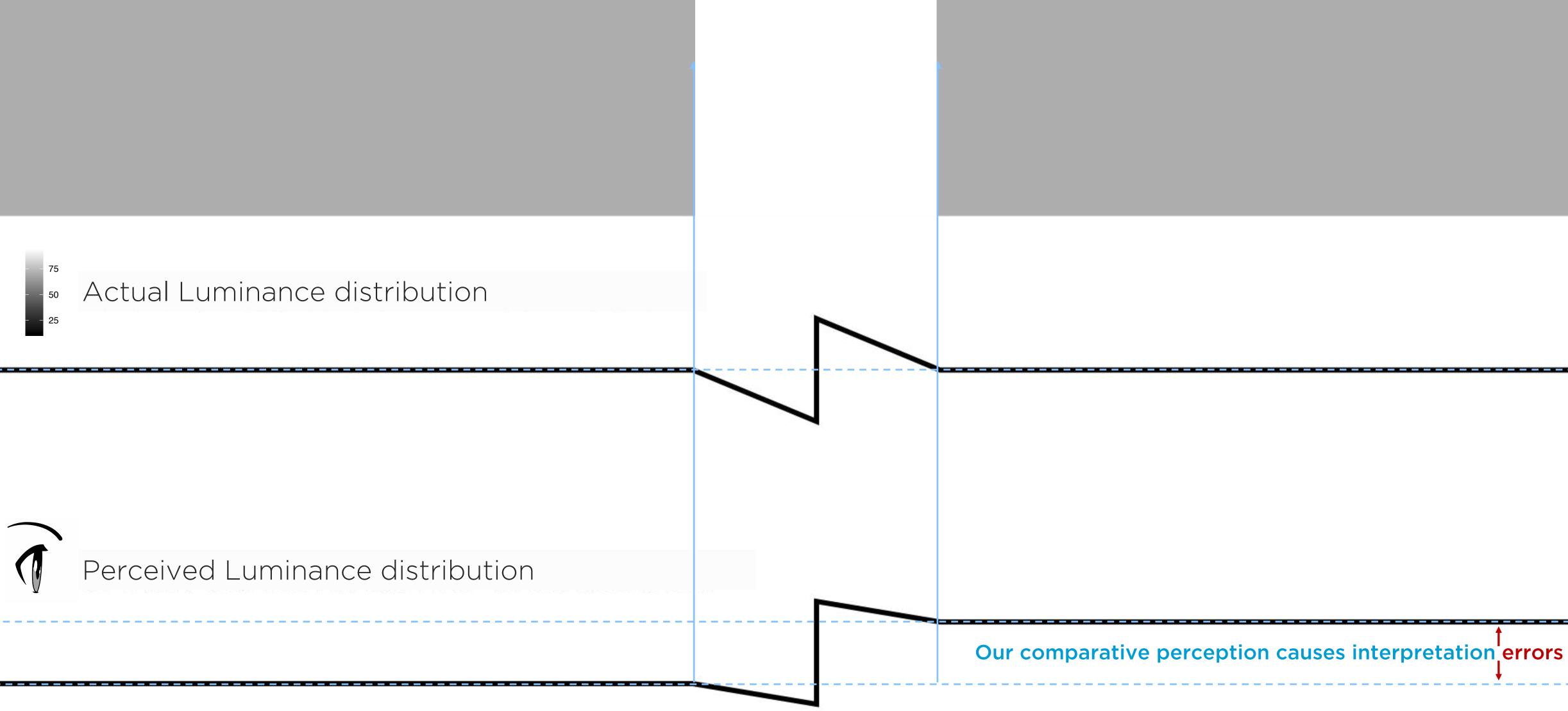
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I 1				
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I 1				
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				VIIII
				(1111)
			111111	111111
			111111	111111
			///////	11/1/1
I 1			VIIIII	UIIII
			11111	
			11111	11111
		111111	111111	VIIIII
I		VIIIII	VIIIII	VIIIII
		VIIIII	111111	UIIII
I			111111	111111
	· · · · · · · · · · · · · · · · · · ·	111111	(1111)	111111
	111111		innn	
	111111	//////	VIIIII	VIIIII
1 1	VIIIIN	VIIIII	111111	UIIII
	//////	VIIIII	11111	111111
	///////	111111	111111	111111
		111111	111111	111111
	∇UUU			
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PRODUCES THIS PSYCHOLOGICAL EFFECT

color humans have evolved to see edge contrasts. We see comparative — not absolute — luminance value.



color humans have evolved to see edge contrasts. We see comparative — not absolute — luminance value.





background and adjacent luminance can interfere with our perception color



Ware, Colin

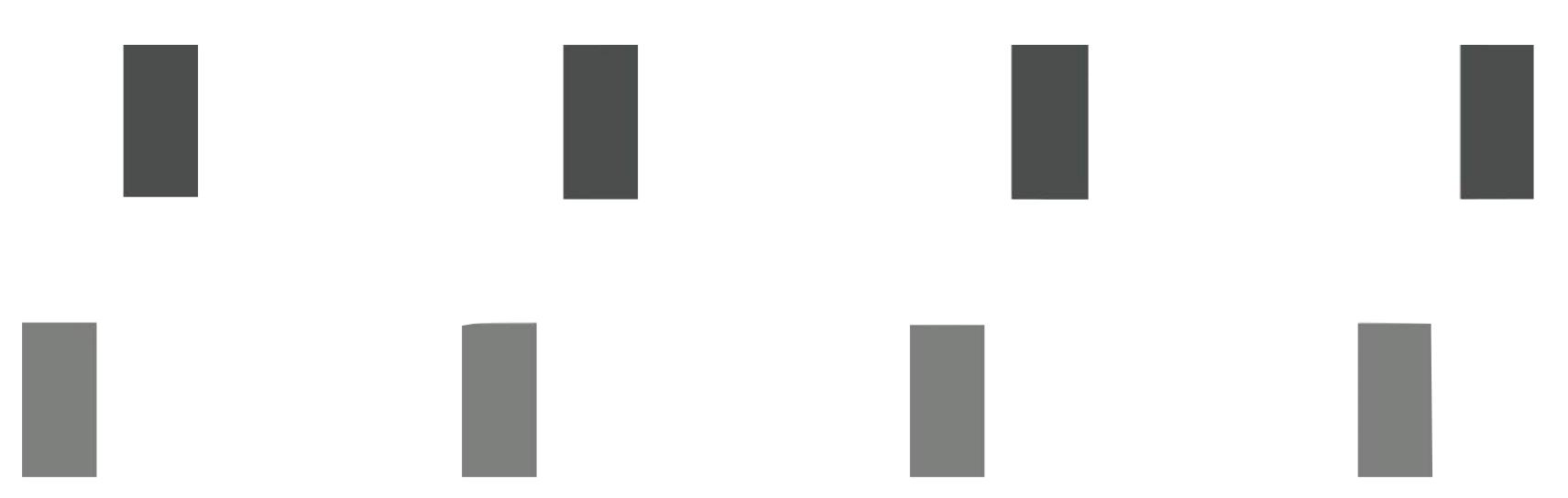




color background and adjacent luminance can interfere with our perception

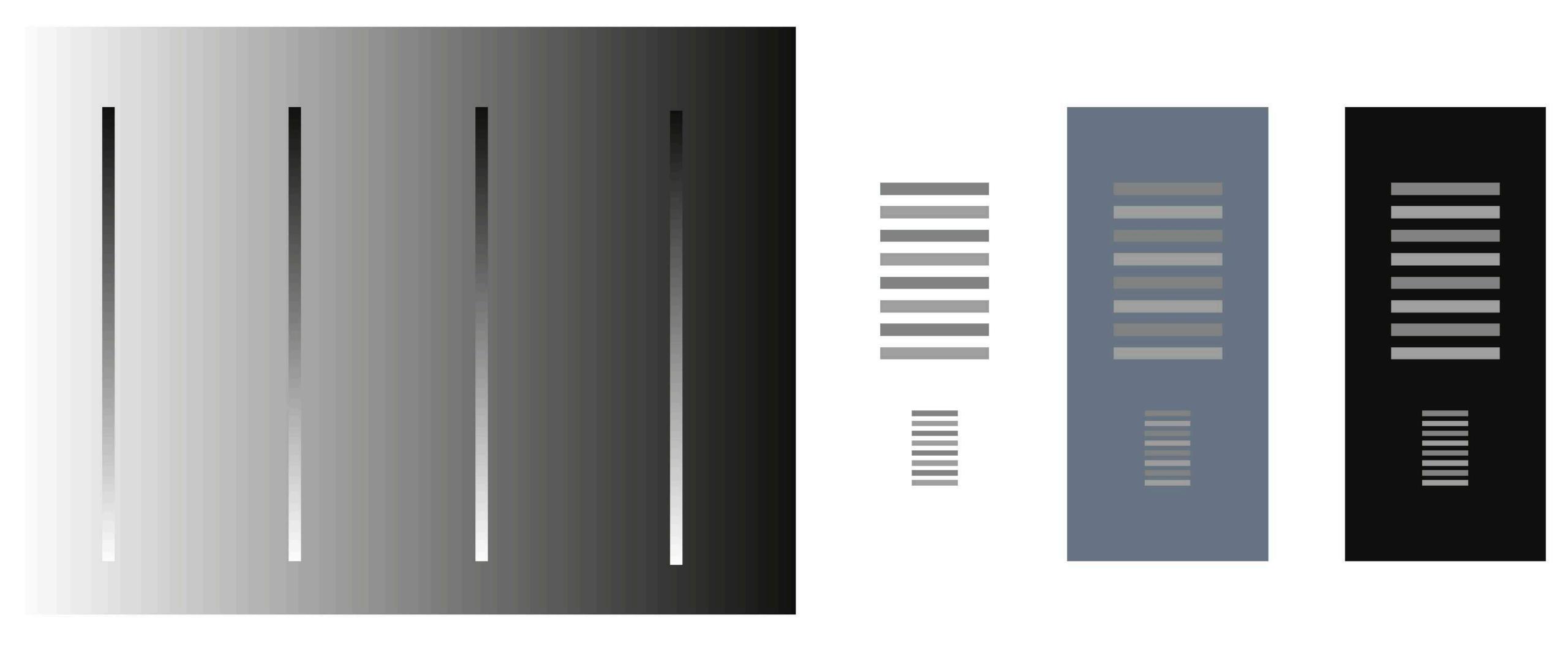






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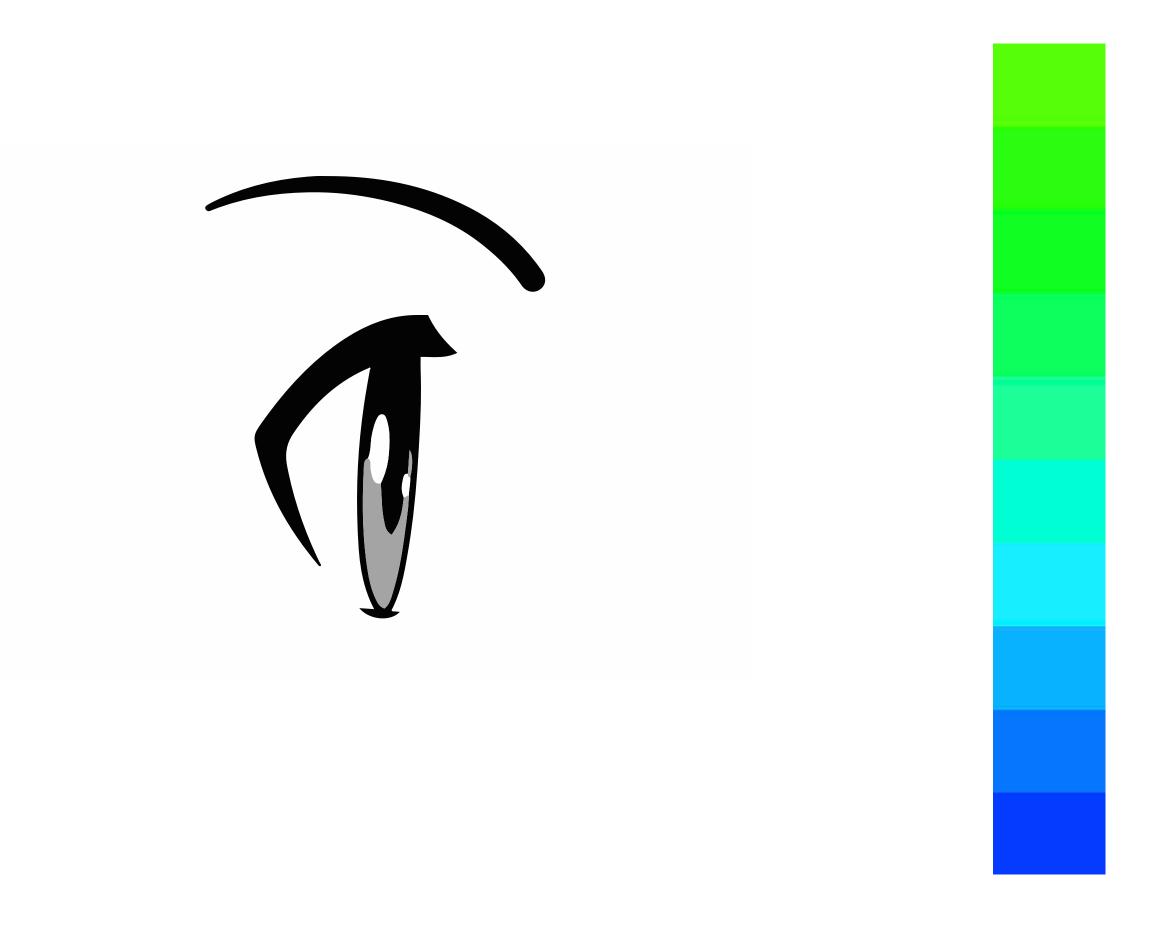


color | high foreground to background luminance contrast enhances shape, lower contrast enhances grayscale





color | as with luminance, hue values in the RGB color space fail to uniformly scale across values.



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color | HSL colorspace is intuitive, but not perceptually uniform in each attribute.

Same luminance or lightness?

HSL(250, 100%, 50%) HSL(250, 100%, 50%)

HSL(60, 100%, 50%) HSL(60, 100%, 50%)



Boronine, Alexei

color | HSL colorspace is intuitive, but not perceptually uniform in each attribute.

Same saturation?

HSL(0, 90%, 40%) HSL(0, 90%, 40%)

HSL(0, 90%, 80%) HSL(0, 90%, 80%)

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Boronine, Alexei

color | HSL colorspace is intuitive, but not perceptually uniform in each attribute.

Equal difference between hues?

HSL(30, 100%, 50%) HSL(30, 100%, 50%)

HSL(50, 100%, 50%) HSL(50, 100%, 50%)

HSL(230, 100%, 50%) HSL(230, 100%, 50%)

HSL(250, 100%, 50%) HSL(250, 100%, 50%)

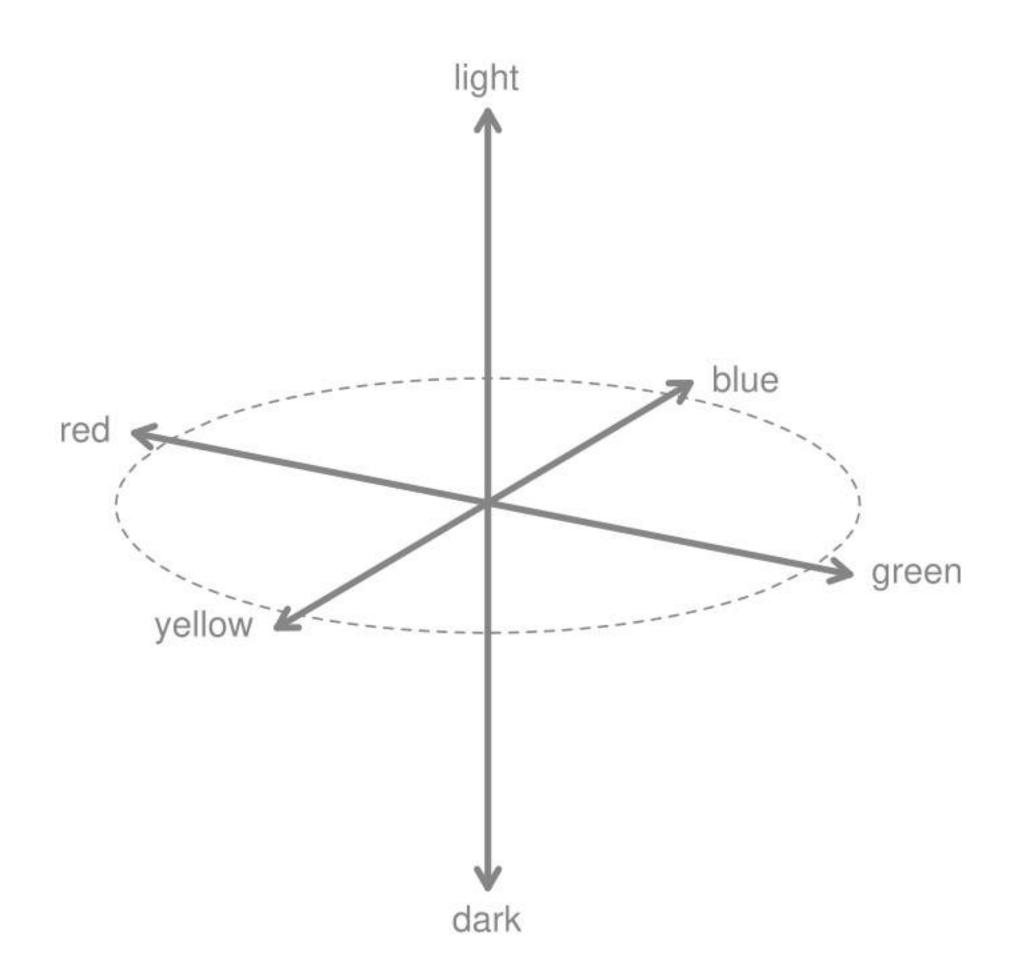
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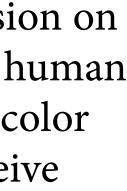
Boronine, Alexei

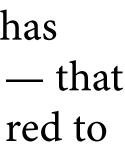
color other color spaces show changes in color we perceive as uniform.



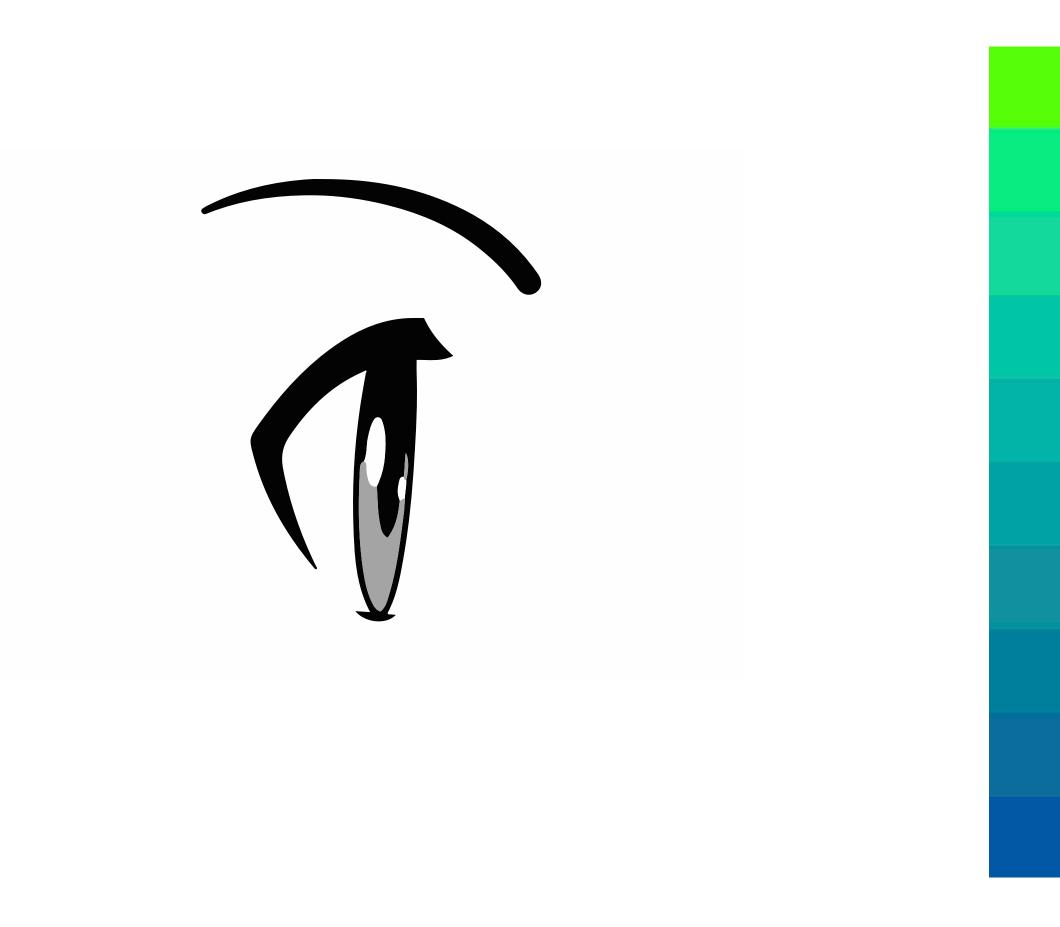
The International Commission on Illumination (CIE) studied human perception and re-mapped color into a space where we perceive color changes uniformly.

Their **CIELuv** color model has two dimensions — u and v — that represent color scales from red to green and yellow to blue.





color | *perceptually uniform color spaces better represent quantity.*



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color example encoding data as perceptually uniform color attributes: R · ggplot2 · HSLuv

Load functions for mapping data to perceptually-uniform color https://github.com/ssp3nc3r/hsluv-rcpp

library(HSLuv)

Create sample data encoded as hue, saturation, luminance

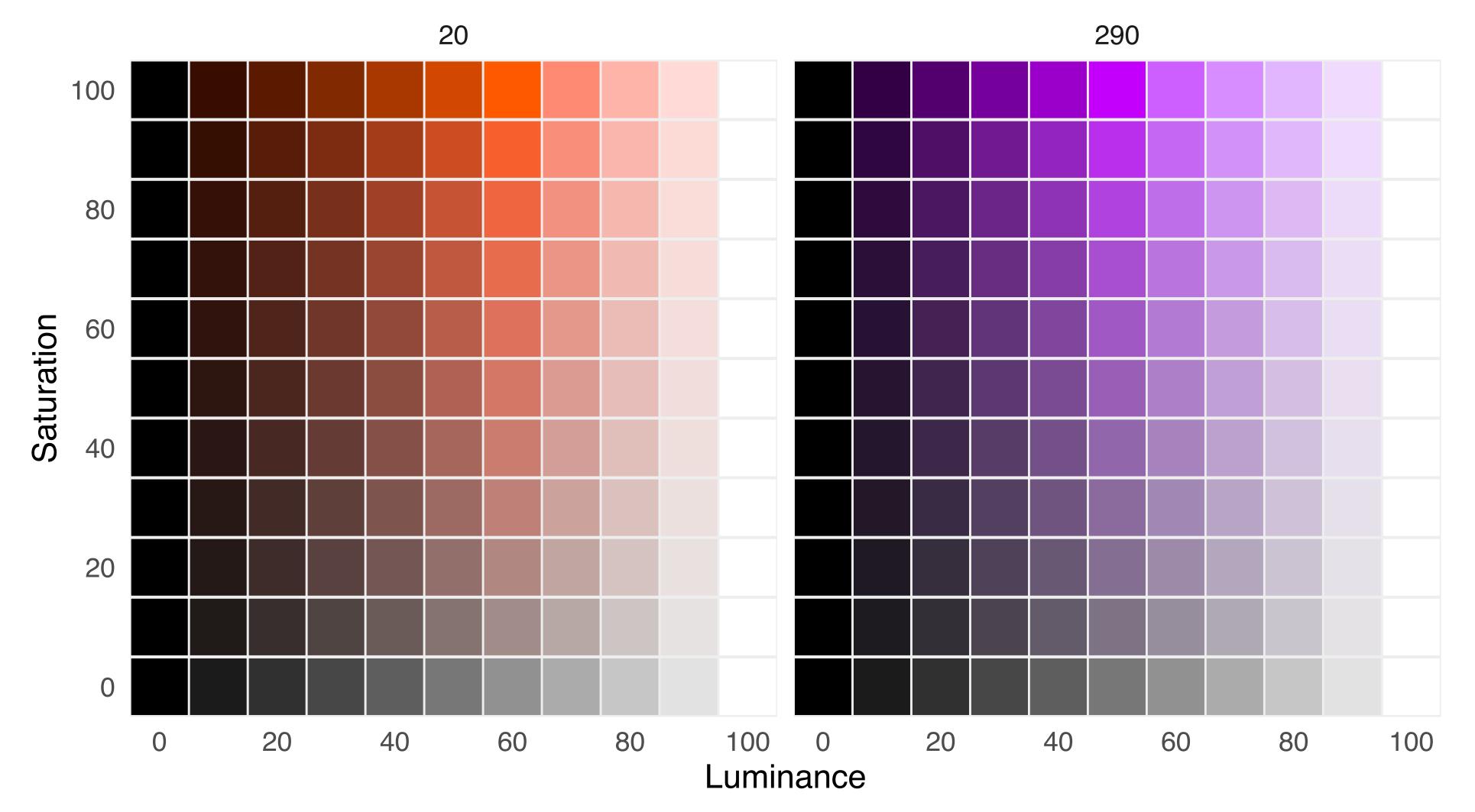
```
df <- expand.grid(H = c(20, 290),
                  S = seq(0, 100, by = 10),
                  L = seq(0, 100, by = 10))
```

Convert HSLuv scaled values to RGB color space as hex code #RRGGBB

```
df$colors <- with(df, hsluv_hex(H, S, L) )</pre>
```

```
Plot data encoded as colors
library(ggplot2)
ggplot(df) +
 theme_minimal() +
 theme(panel.grid = element_blank(),
        axis.text.x.top = element_blank()) +
  geom_point(aes(L, S),
             color = '#eeeeee',
             fill = df$colors,
             size = 10,
             shape = 22) +
  scale_x_continuous(breaks = seq(0, 100, by = 20),
                     sec.axis = sec_axis(~., name = 'Hue')) +
  scale_y_continuous(breaks = seq(0, 100, by = 20)) +
 facet_wrap(~H) +
 labs(x = 'Luminance',
       y = 'Saturation')
```

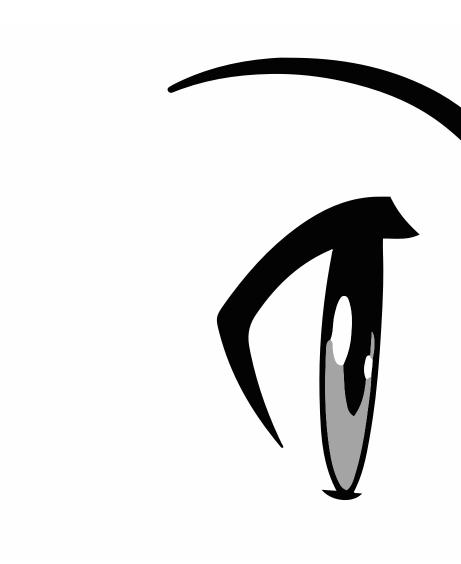
color example encoding data as perceptually uniform color attributes: R · ggplot2 · HSLuv

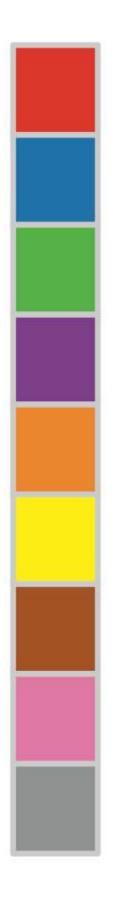


Hue



color perceptually uniform color spaces also help in distinguishing categorical data.





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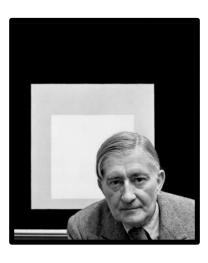


interaction of color

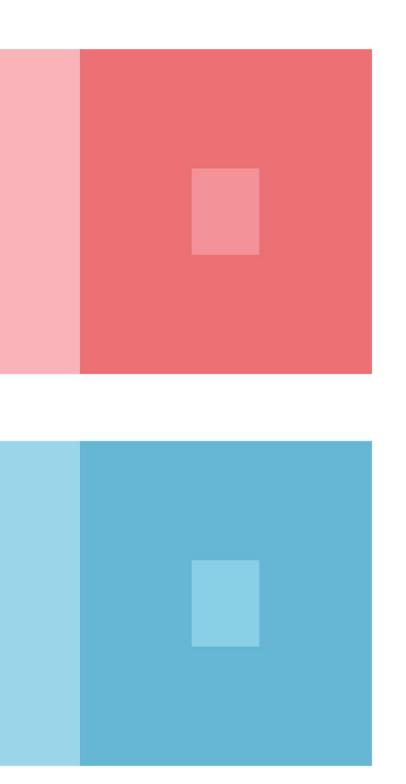
Scott Spencer / 😱 https://github.com/ssp3nc3r 🛛 🗟 scott.spencer@columbia.edu



interaction of color | one color appearing as two

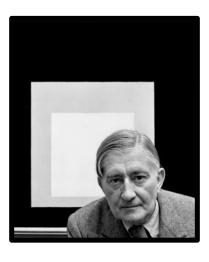


Albers, Josef

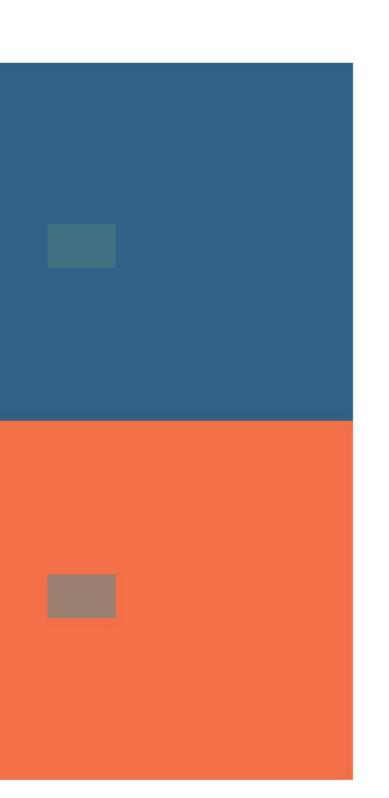




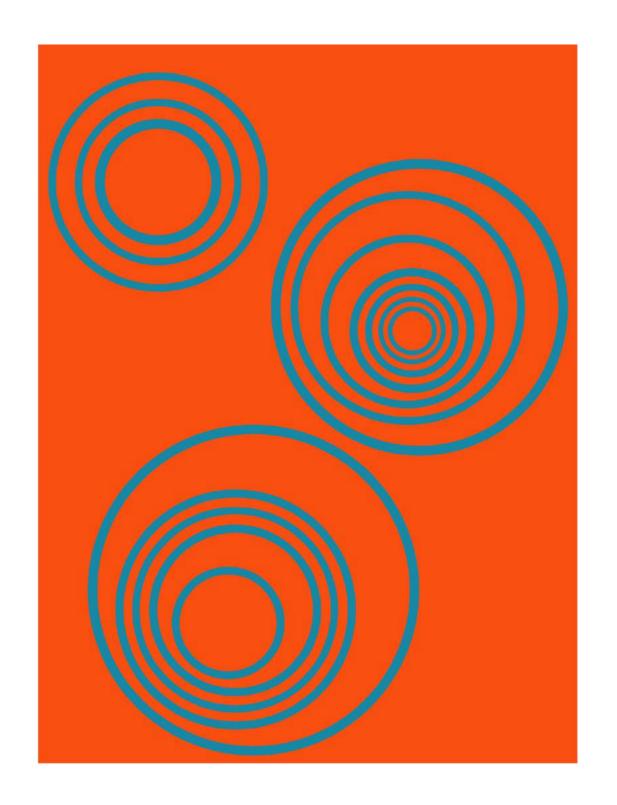
interaction of color | two different colors look alike

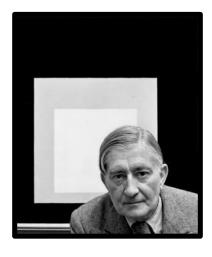


Albers, Josef



interaction of color vibrating boundaries, occurs with contrasting hues of similar luminance





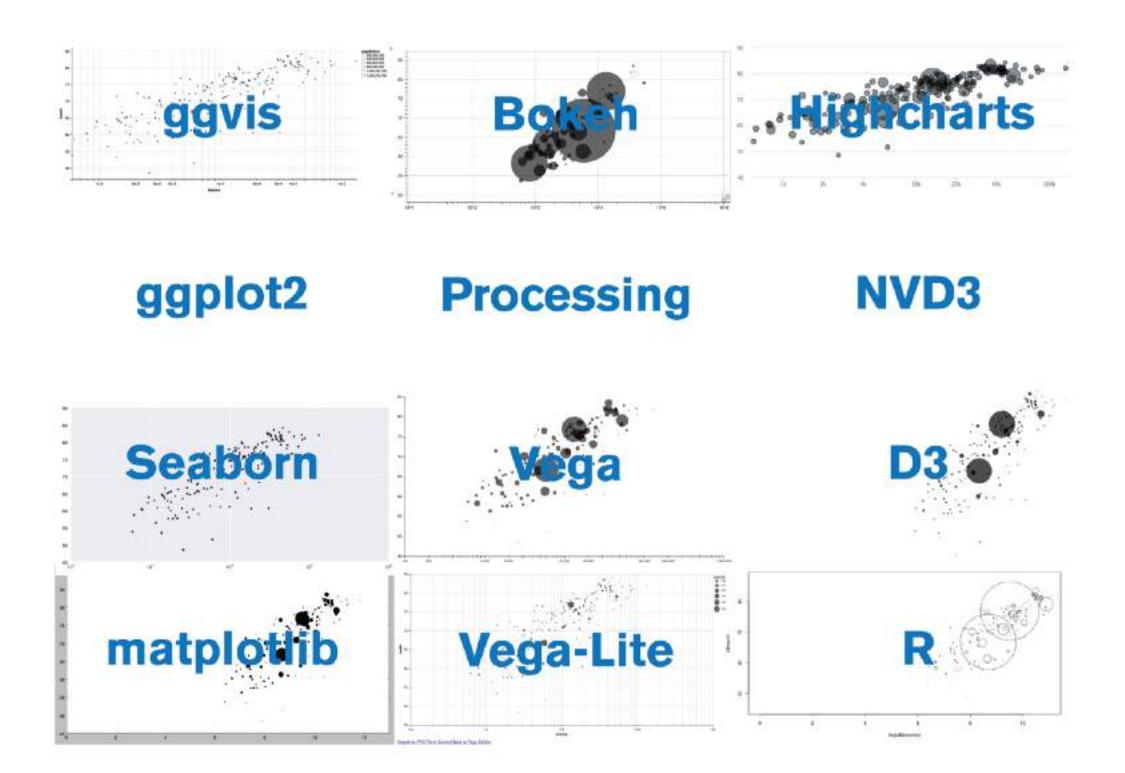
Albers, Josef



perspectives on tools

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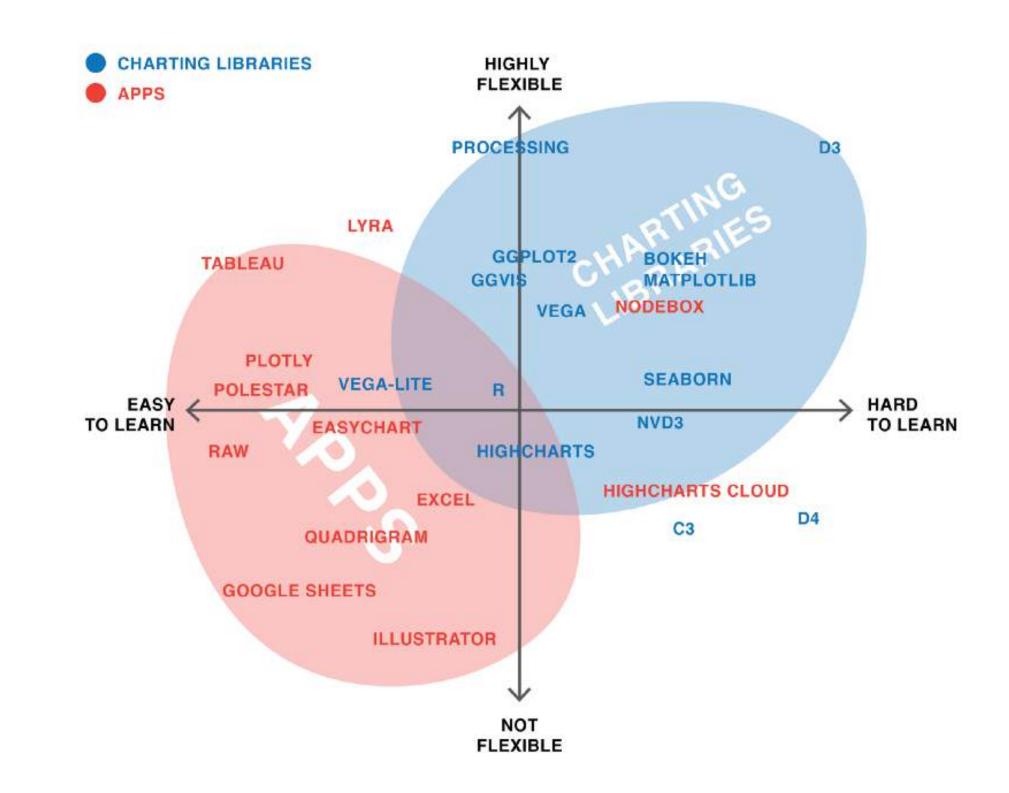






Rost, Lisa Charlotte

thoughts about tools a designer's experiments. One chart created with numerous tools (though more exist)



There are no perfect tools, just good tools for people with certain goals."



thoughts about tools whatever your tools, invest time learning—and applying—design. Do it for your audience.



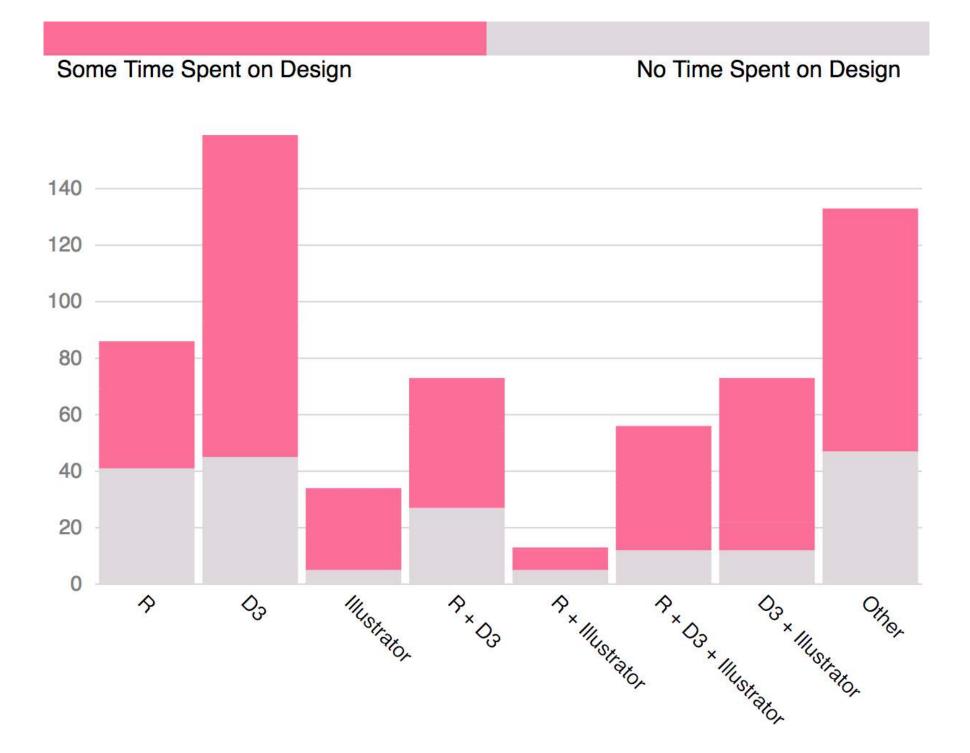
Edward Tufte @EdwardTufte

#Rstats coders and users just can't do words on graphics and typography. Proof: 40 years of clunky, even recent Stanford Statistics textbooks. Publicationquality work requires: R + Adobe Illustrator + reasoning about words on graphics + respect for audience/readers/viewers ♡ 1 4:04 PM - Jun 26, 2018 i See ./philip.sh's other Tweets >

 \checkmark



Meeks, Elijah



Scott Spencer / 🗘 https://github.com/ssp3nc3r 🛛 😰 scott.spencer@columbia.edu



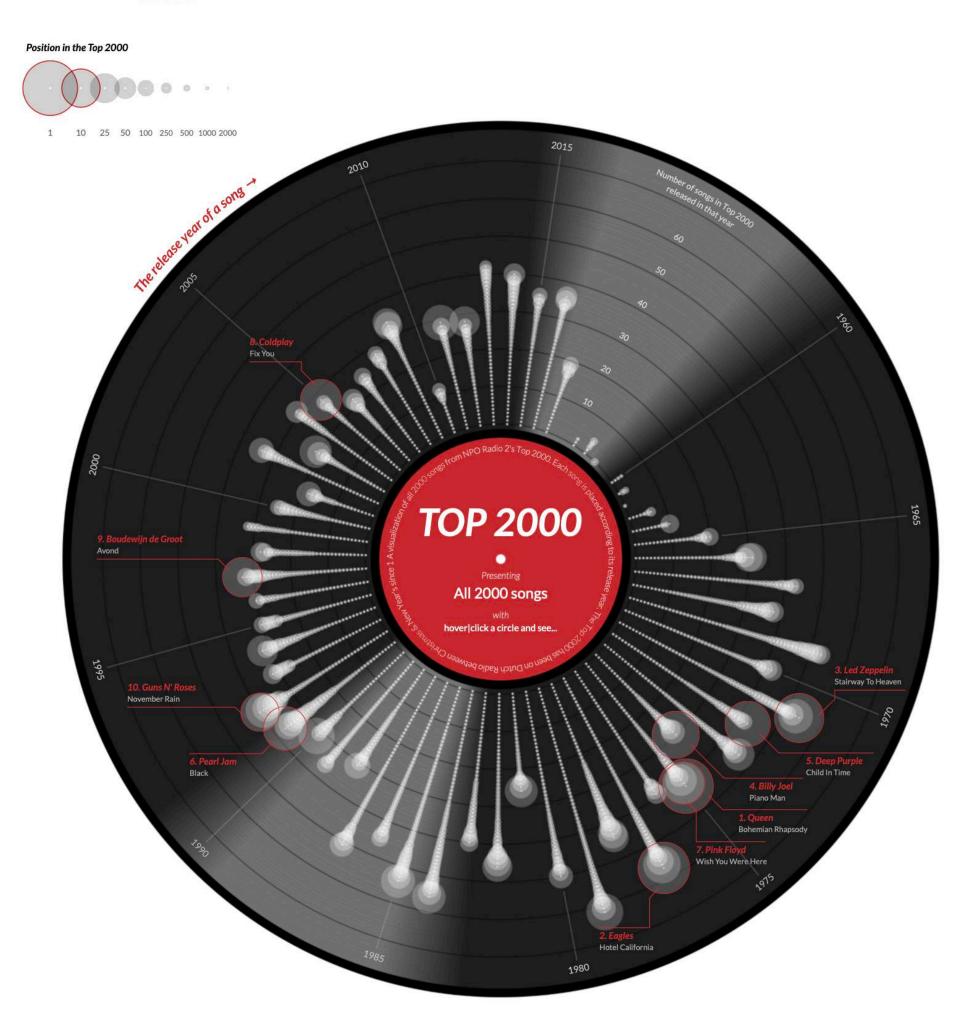
practice in the studio





practice in the studio





When hovering (or clicking on mobile) a circle all the songs of that artist are highlighted and connected by a line. When the song happens to be a collaboration between two artists, you'll see multiple lines, one for each artist.

Created by Nadieh Bremer | Visual Cinnamon

Data from NPO Radio 2

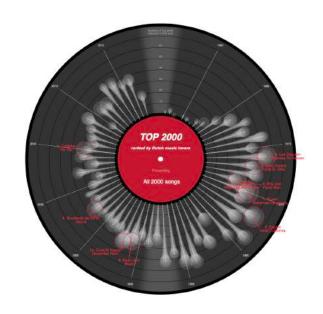
Ga naar de Nederlandse versie

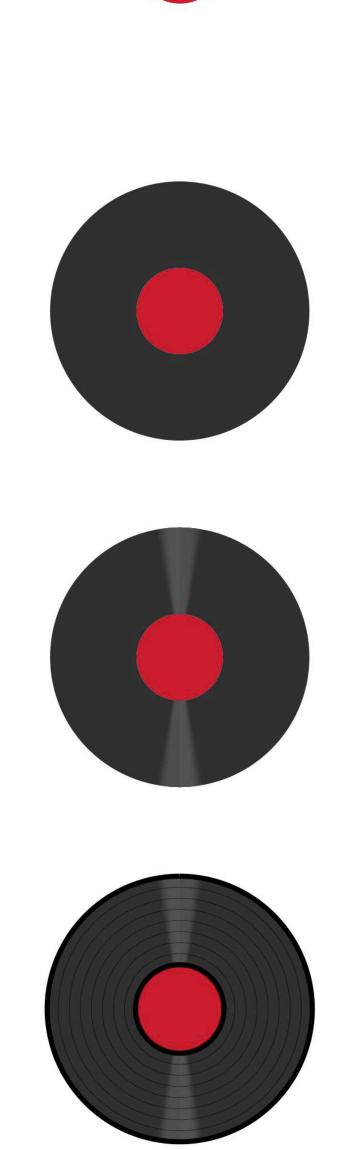
Check out my Top 2000 visuals from 2015 & 2016













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