

Truth, beauty, and data

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andhs.co/umontreal-dataviz

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Plan for today

Facts, truth, and beauty

Data and beauty

Design and beauty

Moral of the story

Facts, truth, and beauty

What is truth?

Core principles of the universe?

Underlying trends in society?

Something transcendental?

Reality?

How do we find truth?

Science!



Neil deGrasse Tyson 
@neiltyson



The good thing about Science is that it's true whether or not you believe in it.

10:41 AM · Jun 14, 2013 · [TweetDeck](#)

14.3K Retweets 8.3K Likes



But wait!

Beware of scientism!

"... promotion of science as the best or only objective means by which society should determine normative and epistemological values"

Science is not the only way

Art

Music

Literature

Religion

Nature

Nothing here is factual...

...but it all reveals truth



Cosette from *Les Misérables*



King Lear

A musical score page for Beethoven's 9th Symphony, specifically the Choral Fantasy section. The page is numbered 116 at the top left. It features three staves: Bassoon (top), Violas & 'cellos (middle), and Double basses (bottom). The music consists of sixteenth-note patterns. Measure 120 begins on the next page, indicated by a repeat sign and measure number.

Beethoven's 9th symphony

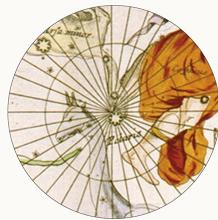
Facts \neq truth

Where does truth come when
there are no facts?

Beauty

Beauty in science

A
BEAUTIFUL
QUESTION



FINDING NATURE'S DEEP DESIGN

FRANK
WILCZEK

WINNER OF THE NOBEL PRIZE IN PHYSICS

This is also true for
science and math
and other more
factual realms

Rhetoric and beauty

λόγος • λέξις

Logos • Lexis

Res • Verba

Essence • Structure

Content • Form

Truth • Beauty

Content + form

**Art is how we translate core,
essential content (or truth!)
to different forms
for specific audiences.**

Truth is beautiful

Truth \neq facts

**Truth comes from aesthetic
combination of content and form**

Facts require beauty to be true

Data and beauty

Just show me the data!

```
head(my_data, 10)
```

```
## # A tibble: 10 x 2
##       x     y
##   <dbl> <dbl>
## 1 55.4  97.2
## 2 51.5  96.0
## 3 46.2  94.5
## 4 42.8  91.4
## 5 40.8  88.3
## 6 38.7  84.9
## 7 35.6  79.9
## 8 33.1  77.6
## 9 29.0  74.5
## 10 26.2  71.4
```

```
mean(my_data$x)
```

```
## [1] 54.26327
```

Seems reasonable

```
mean(my_data$y)
```

```
## [1] 47.83225
```

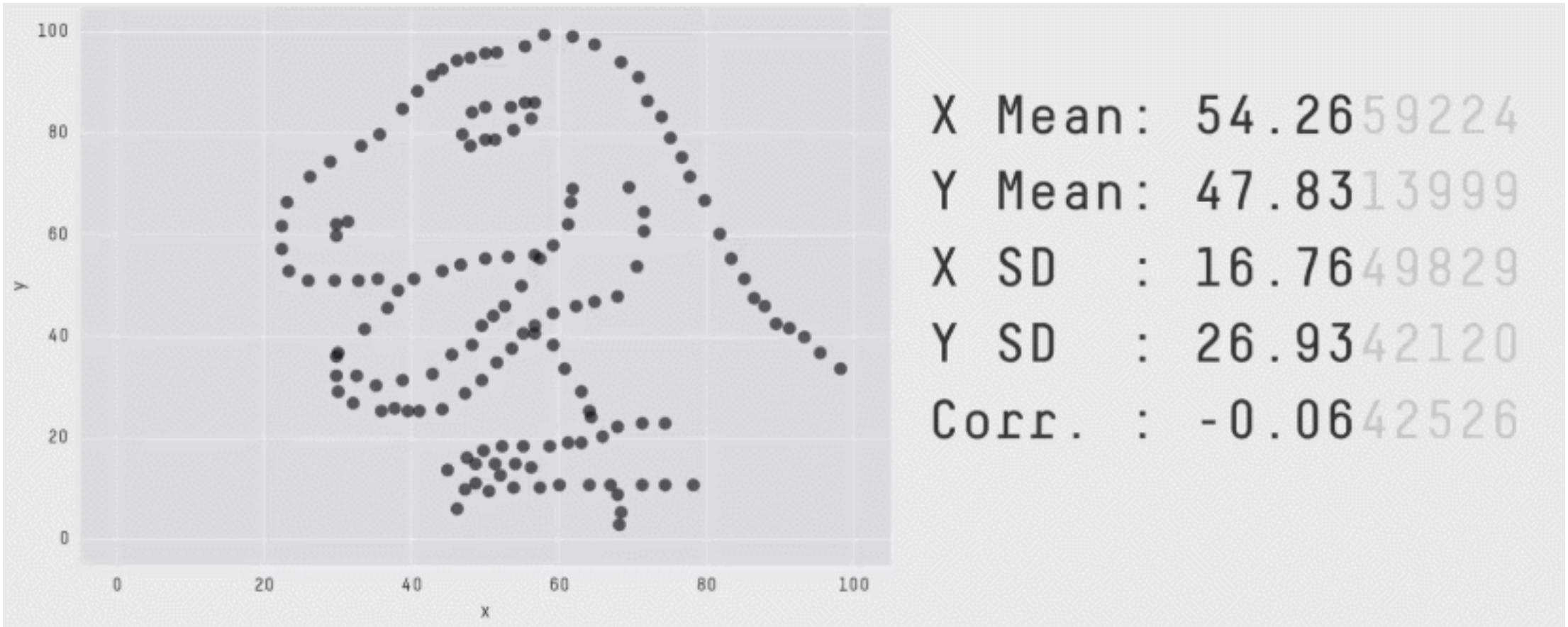
Seems reasonable

```
cor(my_data$x, my_data$y)
```

```
## [1] -0.06447185
```

No correlation

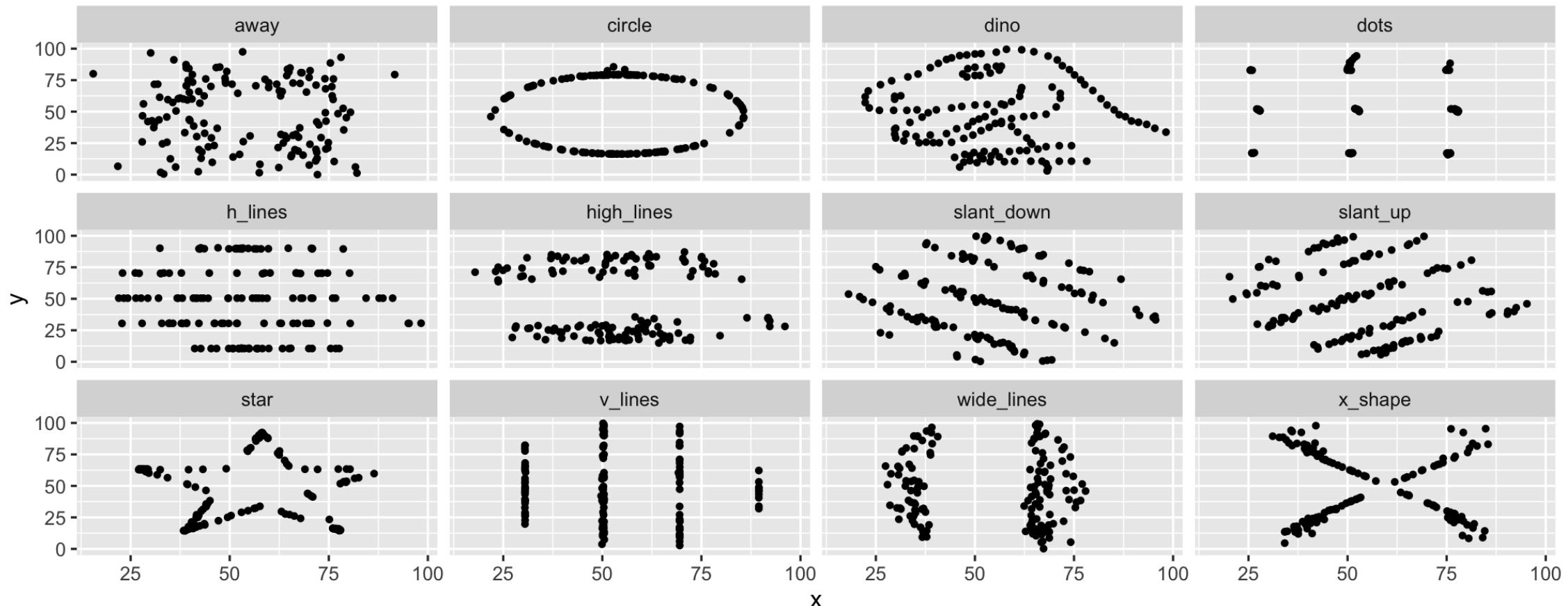
oh no



The Datasaurus Dozen

Raw data is not enough

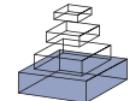
Each of these has the same mean, standard deviation, variance, and correlation



Humans love patterns

frontiers in
NEUROSCIENCE

REVIEW ARTICLE
published: 22 August 2014
doi: 10.3389/fnins.2014.00265



Superior pattern processing is the essence of the evolved human brain

Mark P. Mattson^{1,2*}

¹ Laboratory of Neurosciences, National Institute on Aging Intramural Research Program, Baltimore, MD, USA

² Department of Neuroscience, Johns Hopkins University School of Medicine, Baltimore, MD, USA

Edited by:

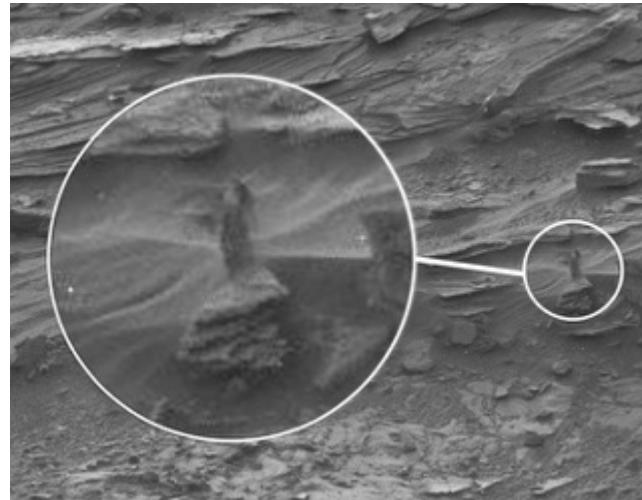
J. Michael Williams, Drexel University, USA

Humans have long pondered the nature of their mind/brain and, particularly why its capacities for reasoning, communication and abstract thought are far superior to other species, including closely related anthropoids. This article considers superior pattern

<https://doi.org/10.3389/fnins.2014.00265>

(Sometimes we love them too much)

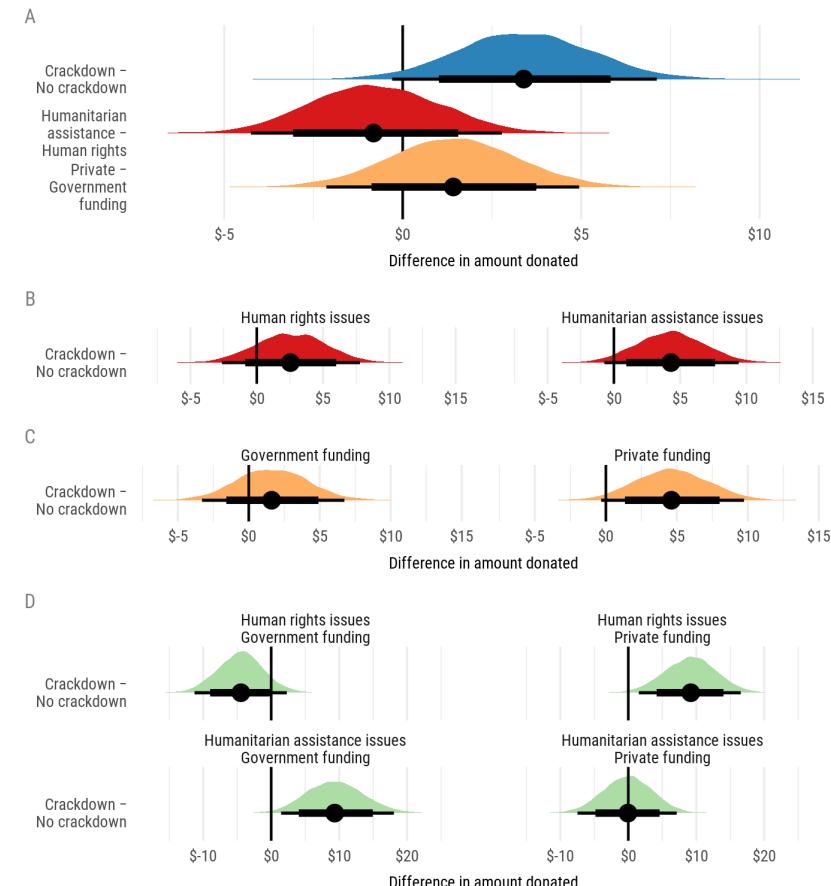
Pareidolia: seeing patterns that aren't there.



Beauty is necessary to see patterns

Table 2: Mean values and differences in means for amount donated in “crackdown” (treatment) and “no crackdown” (control) conditions; values represent posterior medians

H_{1b}	Amount _{Treatment}	Amount _{Control}	Δ	% Δ	$p(\Delta \neq 0)$
Crackdown – No crackdown	16.34	12.93	3.39	26.3%	0.97
<i>Humanitarian assistance – Human rights</i>	14.06	14.85	-0.82	-5.5%	0.67
<i>Private – Government funding</i>	15.13	13.71	1.42	10.4%	0.79
H_{2b} and H_{3b}	Amount _{Crackdown}	Amount _{No crackdown}	Δ	% Δ	$p(\Delta \neq 0)$
Human rights issues	17.4	14.86	2.54	17.2%	0.83
Humanitarian assistance issues	15.91	11.68	4.3	36.9%	0.95
Government funding	13.83	12.24	1.61	13.1%	0.74
Private funding	18.95	14.23	4.62	32.4%	0.97
H_{2b} and H_{3b} (nested)	Amount _{Crackdown}	Amount _{No crackdown}	Δ	% Δ	$p(\Delta \neq 0)$
Human rights issues, Government funding	10.56	15.15	-4.46	-29.5%	0.91
Human rights issues, Private funding	23.76	14.5	9.19	63.8%	0.99
Humanitarian assistance issues, Government funding	21.42	11.89	9.35	77.9%	0.99
Humanitarian assistance issues, Private funding	15.69	15.72	-0.05	-0.3%	0.51



Point shows posterior median; thick black lines show 80% credible interval;
thin black lines show 95% credible interval

Beauty is necessary for truth

What makes a good visualization?

No substantive issues

No perceptual issues

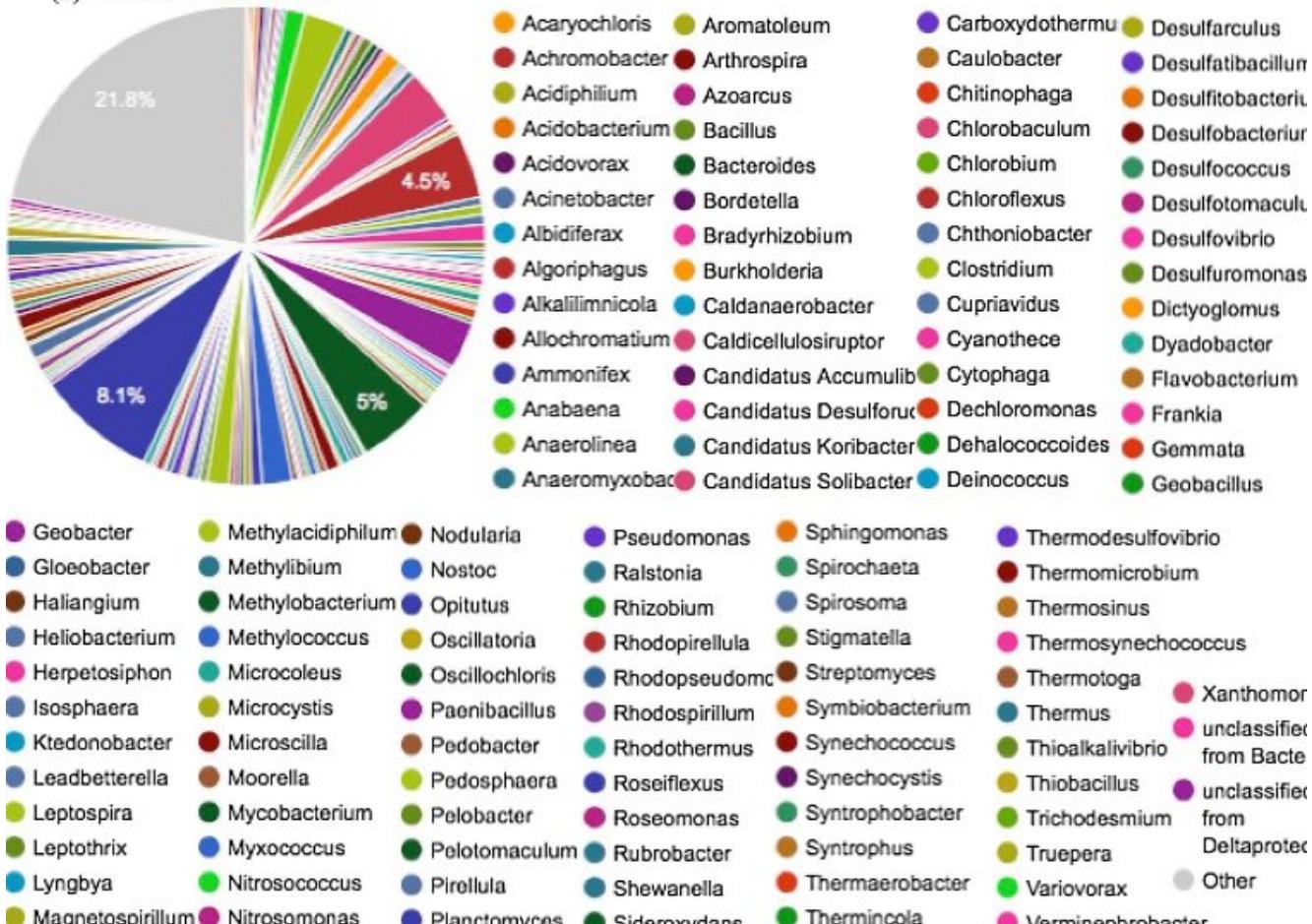
Honesty + good judgment

Good aesthetics

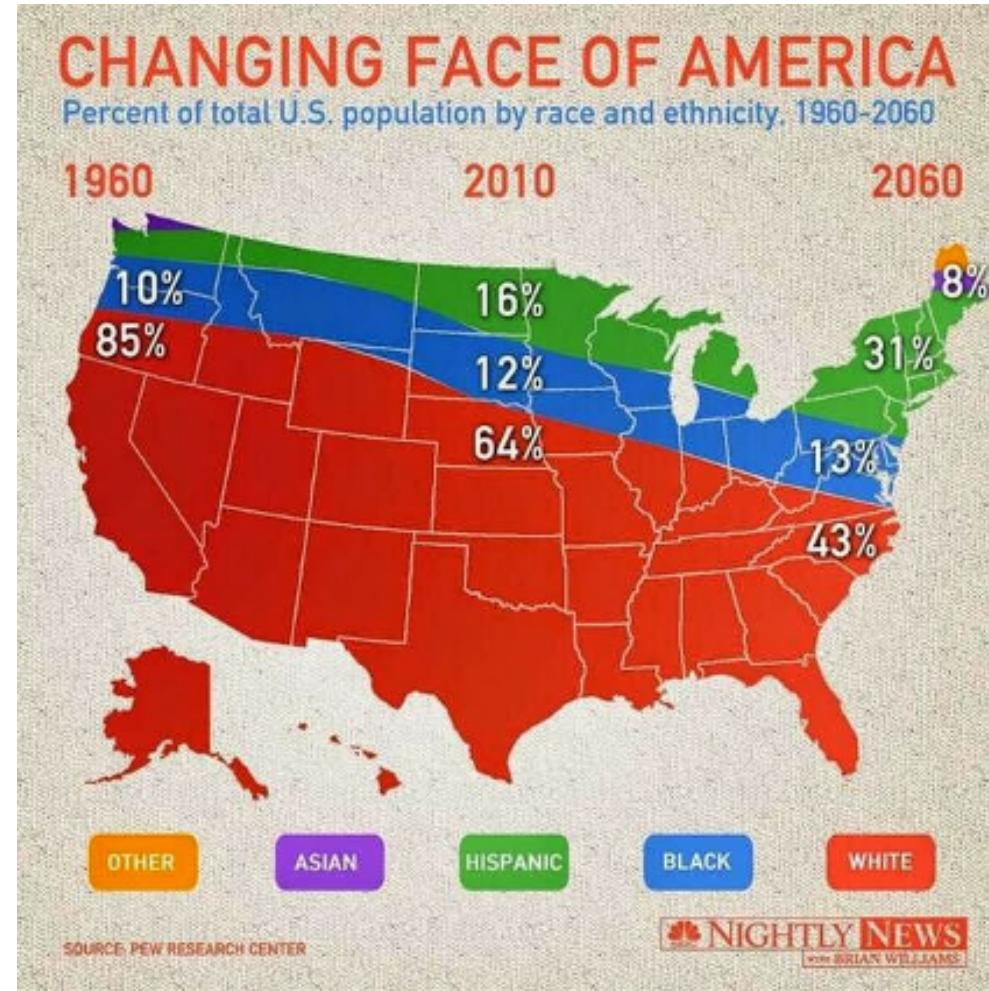
Kieran Healy, *Data Visualization: A Practical Introduction*

What's wrong?

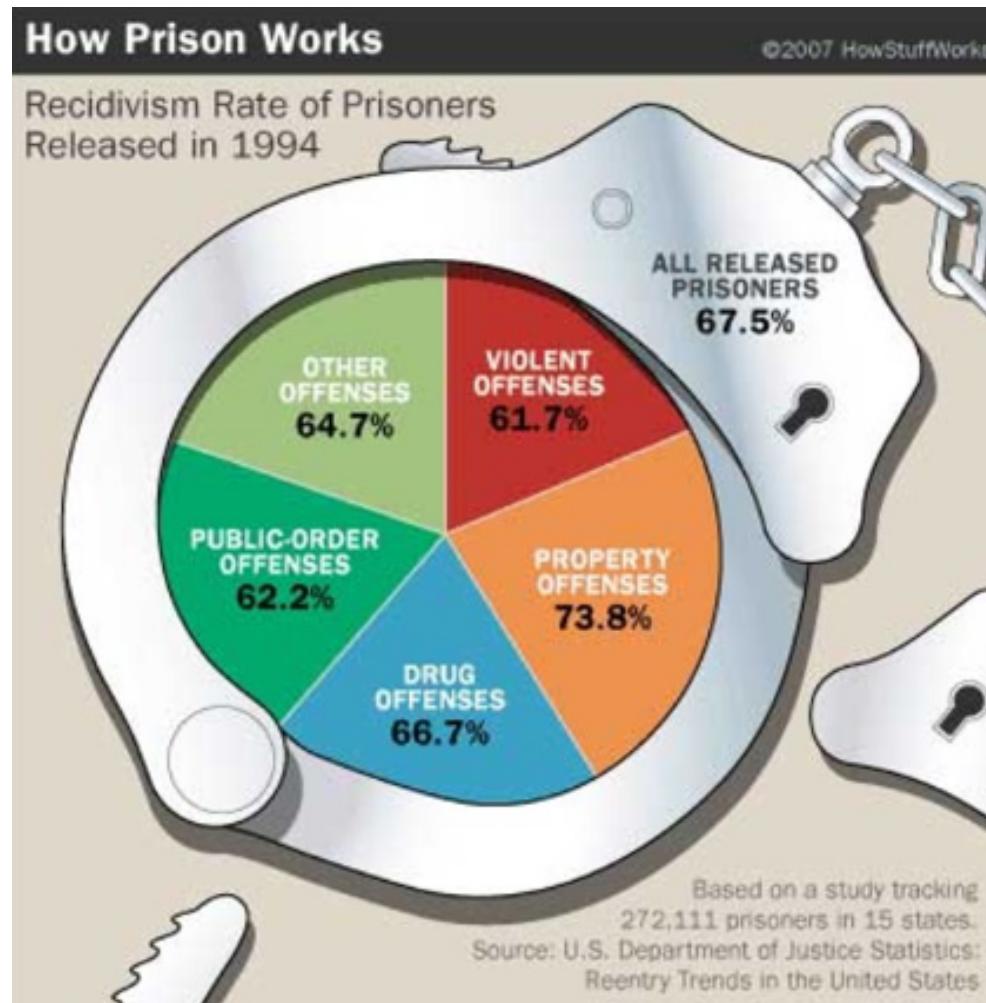
(f) Distribution of Genus



What's wrong?

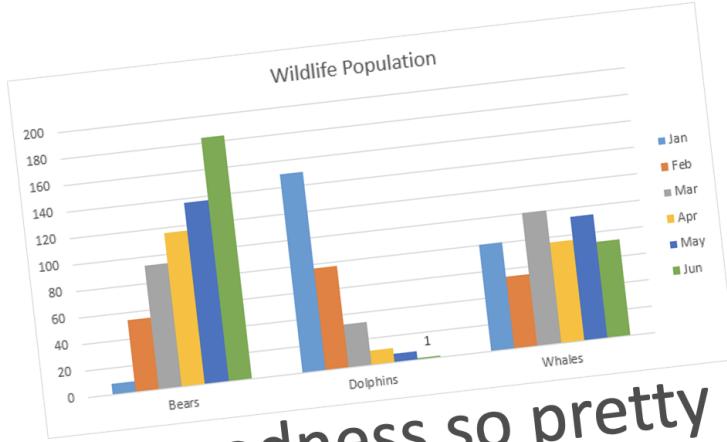


What's wrong?



Design and beauty

Why even care about design?



omgoodness so pretty

I don't need to waste time with design.
My data and findings will
speak for themselves.

How great is Times New Roman, amirite?

Everyone uses Comic Sans,
so it must be good

Plus, Avatar uses Papyrus as the
subtitle font, so it's definitely great

Beauty, stories, and truth

Truth comes from aesthetic combination of content and form.

Raw facts must be communicated through some form.

Beauty shapes that form.

There are aesthetic principles we can follow to create beauty—and truth.

Principles of design

There are thousands of books and centuries of debate and theory about what makes good design.

The easiest and most memorable distillation of these principles is **CRAP**.

CRAP

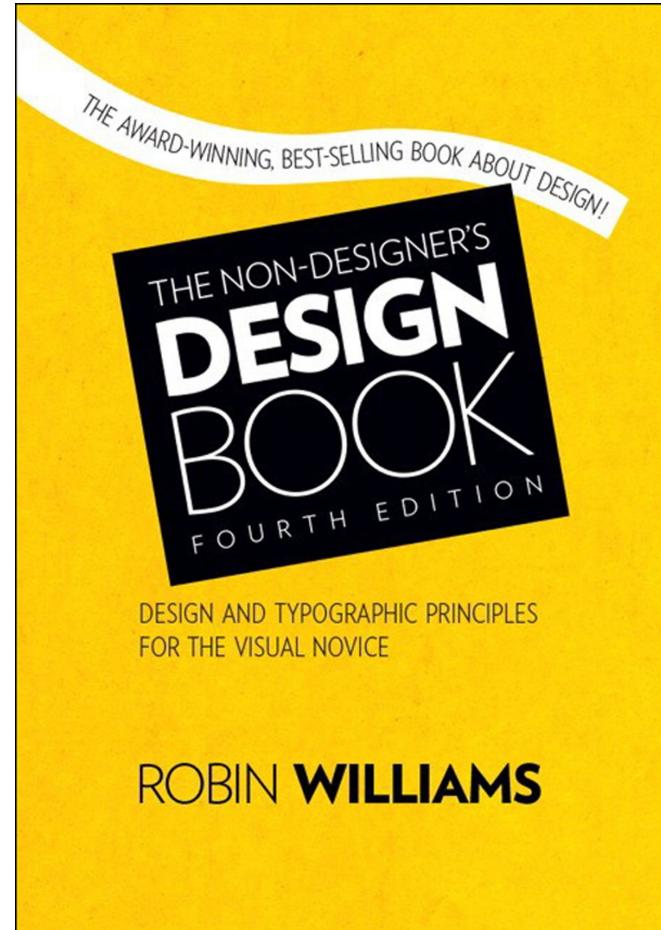
Use these principles as a checklist when creating and critiquing designed objects:

Contrast

Repetition

Alignment

Proximity



Buy this book and your life will change forever.

Contrast

If two items are not exactly
the same, make them different.
Really different.

Don't be a wimp.

Typographic contrast: Family

Use contrasting type families

Serif + Sans serif

Script + Serif

Slab + Sans serif

etc.

Serif

Sphinx of black quartz, judge my vow

Sans serif

Sphinx of black quartz, judge my vow

Slab serif

Sphinx of black quartz, judge my vow

Script

Sphinx of black quartz, judge my vow

Monospaced

Sphinx of black quartz, judge my vow

Typographic contrast: Family

Add contrast in family

Here's a heading

 Lorem ipsum dolor sit amet,
 consectetur adipisicing elit, sed
 do eiusmod tempor incididunt ut
 labore et dolore magna aliqua.

Here's a heading

 Lorem ipsum dolor sit amet,
 consectetur adipisicing elit, sed
 do eiusmod tempor incididunt ut
 labore et dolore magna aliqua.

Typographic contrast: Weight

Use contrasting weights in same type family

Bold + Regular

Regular + Extra light

Black + Light

etc.

Extra light

Sphinx of black quartz, judge my vow

Light

Sphinx of black quartz, judge my vow

Regular

Sphinx of black quartz, judge my vow

Semi bold

Sphinx of black quartz, judge my vow

Bold

Sphinx of black quartz, judge my vow

Black

Sphinx of black quartz, judge my vow

Typographic contrast: Weight

Add contrast in weight

Here's a heading

 Lorem ipsum dolor sit amet,
 consectetur adipisicing elit, sed
 do eiusmod tempor incididunt ut
 labore et dolore magna aliqua.

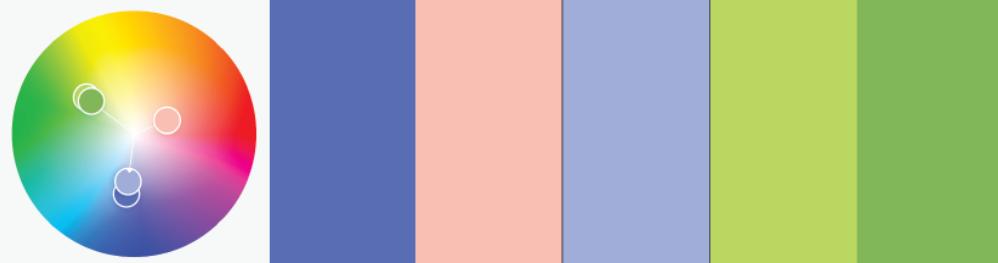
Here's a heading

 Lorem ipsum dolor sit amet,
 consectetur adipisicing elit, sed
 do eiusmod tempor incididunt ut
 labore et dolore magna aliqua.

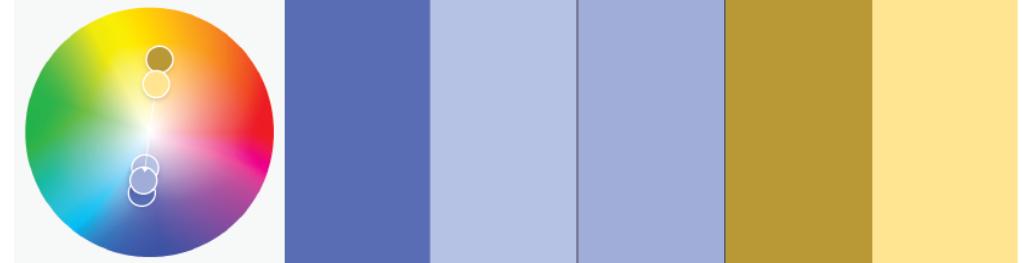
Color contrast

Color theory

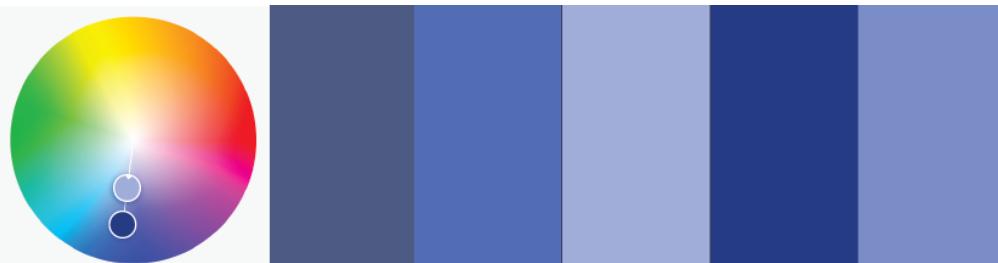
color.adobe.com



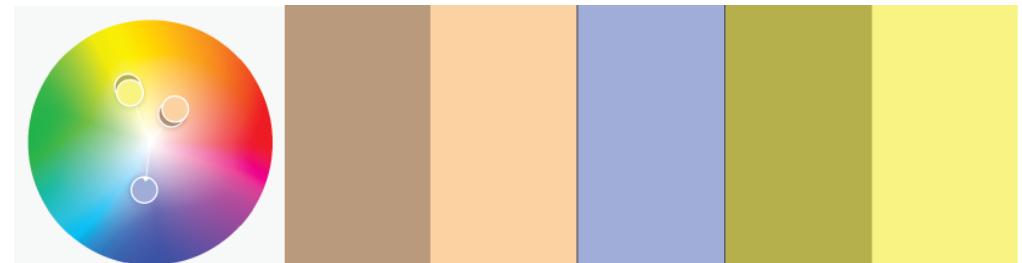
Triad



Complementary



Monochromatic



Split complementary

Color contrast



Colors extracted from an image at color.adobe.com

Usability and accessibility

Perceptually uniform colors

Values close to each other use similar colors,
and values far from each other use different colors

Colorblind-safe colors

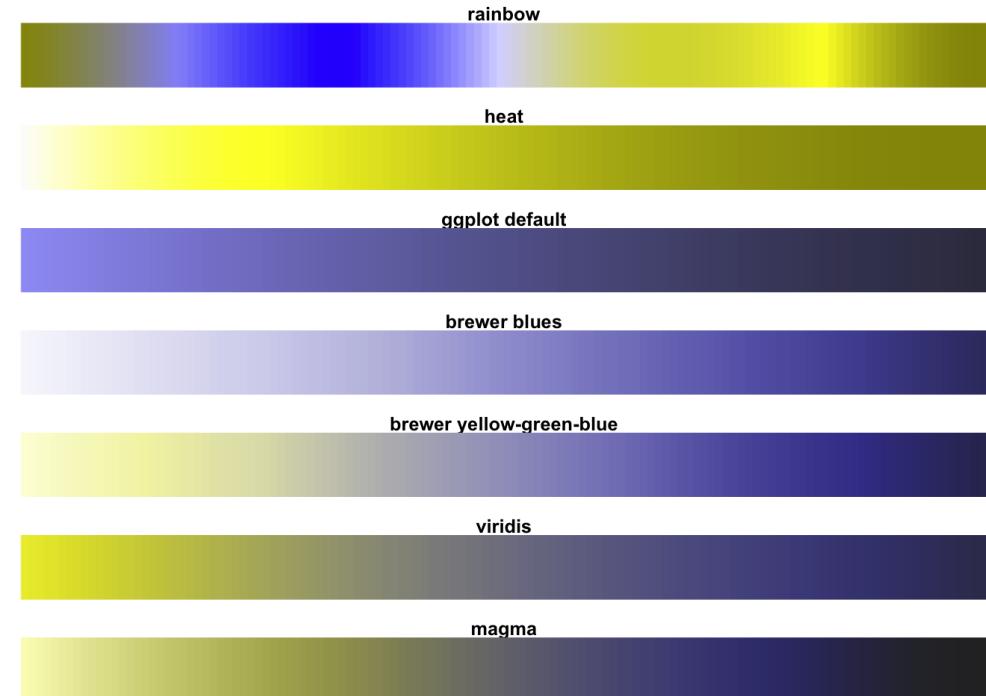
8% of men & 0.05% of women have some form of color blindness

Colors should be distinguishable by people
with common forms of color blindness

Perceptually uniform colors

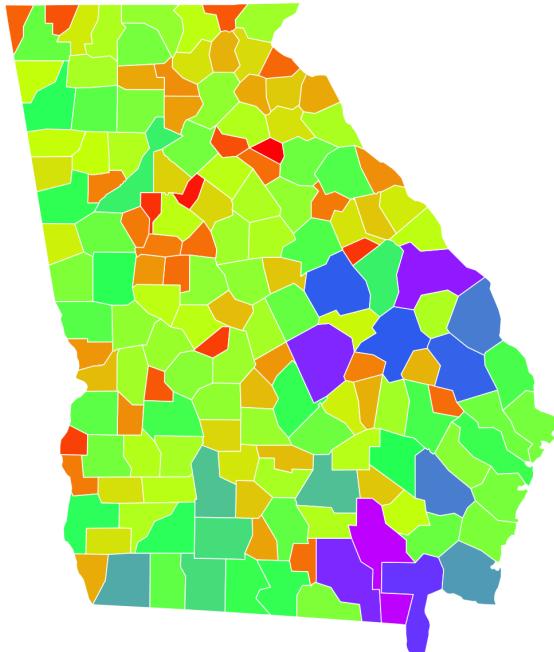


Traditional palettes vs. viridis

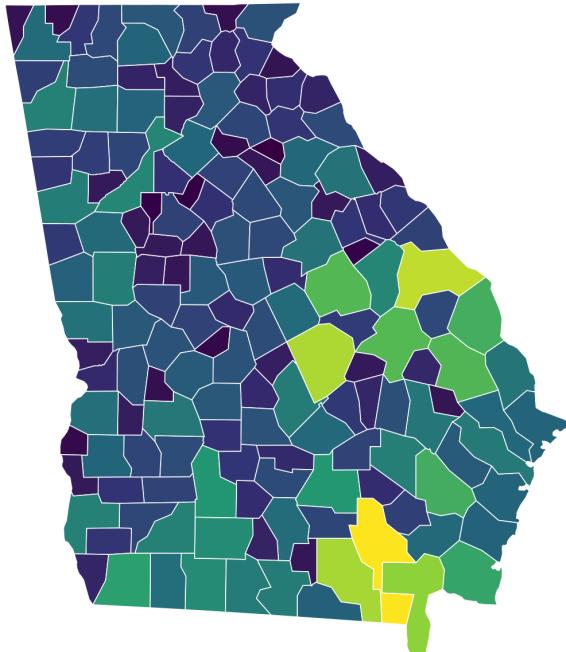


Traditional palettes vs. viridis as seen with deuteranopia

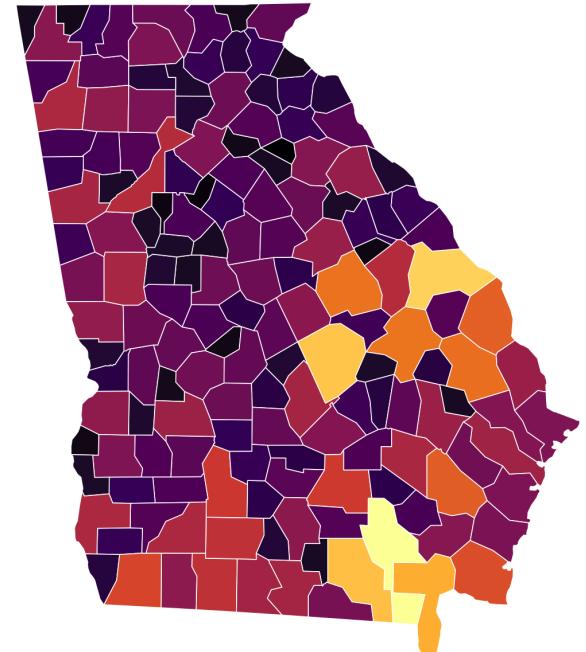
Perceptually uniform colors



Georgia counties filled by area,
rainbow palette (NOT GOOD)



Georgia counties filled by area,
viridis::viridis palette



Georgia counties filled by area,
viridis::inferno palette

Repetition

Repeat some aspect
of the design throughout
the entire piece.

Things to repeat

Colors

Fonts

Families, weights, sizes

Graphical elements

Alignments

WE HELP PEOPLE BUILD BETTER FUTURES FOR THEMSELVES

Oxfam provides grants and technical support to local organizations around the world to support long-term solutions that help people grow nutritious food, access land and clean water, and—as one of our programs in Jordan illustrates—obtain decent work and fair wages.

MORE THAN A PIPE DREAM

Water scarcity is a major problem in Jordan. Aging water infrastructure and a rapidly increasing population—the conflict in Syria has driven more than 650,000 Syrians to settle in Jordan—have created a situation where every drop counts.

Currently, more than 40 percent of Jordan's water leaks out of broken pipes, so knowing how to fix them is critical. When Oxfam and its partners started a program in northern Jordan to improve the water sector, we made training plumbers—particularly women—a priority.

Funding from the Canadian government helped us equip more than 400 women with basic plumbing skills not only to fix leaks in their homes but to acquire enough plumbing know-how to enter the labor market.

Mariam Tawfeeq Matlaq, 44, picked up a wrench five years ago and started her own business north of Amman soon after. "As soon as I received the training to be a plumber, I had a dream to open a shop," she says, though it wasn't easy to get off the ground. "There are negative perceptions of a woman plumbing in my community. The competition between me and the male plumbers can be difficult."

Still, she says, "I've proved it to people, my community, and the world around me that women can do anything, whether it is conventional or not."

Matlaq has trained many women and recommends them for jobs when she can.

"Women here want to work," she says. "We want opportunities, but often there aren't any for us. We need support from organizations to keep growing these opportunities."



ABOVE, TOP: Mariam Tawfeeq Matlaq fixes the water tank on her rooftop in Zarqa, north of Amman, Jordan, after receiving training from Oxfam on basic plumbing skills. Now she's training other women to become plumbers.

ABOVE, BOTTOM: Matlaq opened her hardware store a year ago in Zarqa and employs several male plumbers who work across the city.

OPPOSITE: "I have been a plumber for five years now. I like it a lot—I especially like the challenges I face," Matlaq says.

PHOTOS: Abbie Trayler-Smith/Oxfam

WE SAVE LIVES IN DISASTERS AND CONFLICTS

We work with local organizations to provide assistance during conflicts and disasters, but we also partner with community and national advocates to change the conditions that create them. That's the case in Central America and Mexico, where Oxfam has worked for many decades.

LITTLE CHOICE BUT TO LEAVE

Last fall, Nelson Chavez left his home in El Salvador because he couldn't make enough money to support his family. He worked for a honey producer, bottling honey and selling it from his home. But his income only covered half of what his family needs.

Chavez was one of thousands of people fleeing El Salvador, Guatemala, Honduras, and Mexico to look for a better life in the United States. "What we have in common is the necessity to migrate," he said. "The majority of us do hard work like construction and farm labor, and we are poor. We live on what we make each day."

Oxfam and its partners provided immediate help to Chavez and others in Guatemala with food packages, portable toilets, drinking water, vitamins and rehydration drinks, canopies, and hygiene kits—which included information about how to report acts of violence and human trafficking. In Mexico, we distributed water, thermoses, pots of Vaseline for sore feet, and oral rehydration salts.

But we also provided financial support to local migrants' rights organizations and shelter networks, and called on the governments of Guatemala, Mexico, and the US to protect and guarantee the rights of asylum-seekers and ensure that children aren't separated from their families.

Oxfam President and CEO Abby Maxman visited Tijuana, Mexico, in January to meet with migrants, asylum-seekers, and partner organizations. "The migrants I met in Tijuana are no different than the people who first built our country and what generations of Americans have done: arrive with aspirations to build a better life," she said. "We should live up to our legacy as a welcoming nation that was built on the hard work of immigrants, rather than demonize and criminalize them."



ABOVE, TOP: Nelson Chavez, from El Salvador, left his home and walked to the Guatemala-Mexico border. "There are almost no opportunities to work in my country." Elizabeth Stevens/Oxfam

ABOVE, BOTTOM: Oxfam staff Alejandro Orozco and Sherry Toc deliver an inflatable mattress to a man arriving at a shelter in Tecún Umán, Guatemala. Alyssa Eisenstein/Oxfam

OPPOSITE: People from La Trinidad, Guatemala, evacuate their community after the eruption of Fuego volcano last June. Oxfam helped those who were displaced. James Rodriguez/Panos for Oxfam America

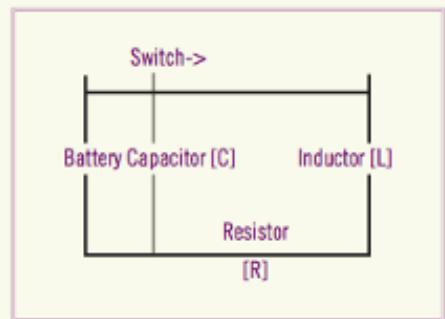
Alignment

Every item should have a visual connection with something else on the page.

Alignment

Example 6: Value of a resistor in an electrical circuit.

Find the value of a resistor in an electrical circuit which will dissipate the charge to 1 percent of its original value within one twentieth of a second after the switch is closed.



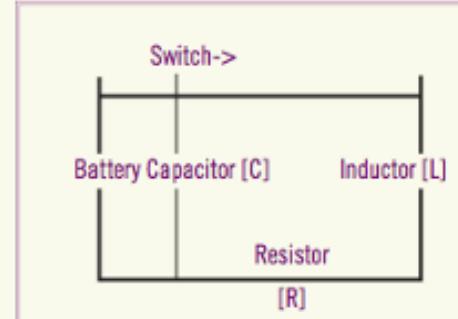
q0=	9	volts
q(t)=	0.09	volts
t=	0.05	seconds
L=	8	henrys
C=	0.0001	farads
R=	300	ohms
q(t)=	0.253889	

1/[L*C_]	1250
[R_/(2*L)]^2	351.5625
SQRT(B15-B16)	29.973947
COS(T*B17)	0.07203653
-R_*T/(2*L)	-0.9375
Q0+EXP (B 19)	3.52445064

Bad alignment

Example 6: Value of a resistor in an electrical circuit.

Find the value of a resistor in an electrical circuit which will dissipate the charge to 1 percent of its original value within one twentieth of a second after the switch is closed.



q0=	9	volts
q(t)=	0.09	volts
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L=	8	henrys
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1/[L*C_]	1250
[R_/(2*L)]^2	351.5625
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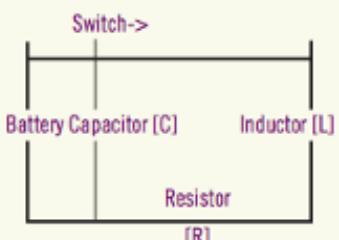
Good alignment—everything is connected to something

Alignment + repetition

Share lines and repeat alignments where possible.

Example 6: Value of a resistor in an electrical circuit.

Find the value of a resistor in an electrical circuit which will dissipate the charge to 1 percent of its original value within one twentieth of a second after the switch is closed.

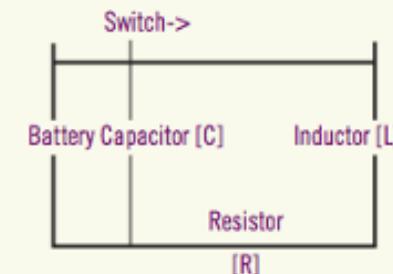


$$\begin{aligned}1/[L \cdot C] &= 1250 \\(R_{\text{series}}/(2 \cdot L))^2 &= 351.5625 \\ \sqrt{B15 \cdot B16} &= 29.973947 \\ \cos(\pi \cdot B17) &= 0.07203653 \\ -R_{\text{series}} \cdot T/(2 \cdot L) &= -0.9375 \\ Q_0 + \exp(B19) &= 3.52445064\end{aligned}$$

$$\begin{aligned}q_0 &= 9 \text{ volts} \\ q(t) &= 0.09 \text{ volts} \\ t &= 0.05 \text{ seconds} \\ L &= 8 \text{ henrys} \\ C &= 0.0001 \text{ farads} \\ R &= 300 \text{ ohms} \\ q(t) &= 0.253889\end{aligned}$$

Example 6: Value of a resistor in an electrical circuit.

Find the value of a resistor in an electrical circuit which will dissipate the charge to 1 percent of its original value within one twentieth of a second after the switch is closed.



$$\begin{aligned}q_0 &= 9 \text{ volts} \\ q(t) &= 0.09 \text{ volts} \\ t &= 0.05 \text{ seconds} \\ L &= 8 \text{ henrys} \\ C &= 0.0001 \text{ farads} \\ R &= 300 \text{ ohms} \\ q(t) &= 0.253889\end{aligned}$$

$$\begin{aligned}1/[L \cdot C] &= 1250 \\(R_{\text{series}}/(2 \cdot L))^2 &= 351.5625 \\ \sqrt{B15 \cdot B16} &= 29.973947 \\ \cos(\pi \cdot B17) &= 0.07203653 \\ -R_{\text{series}} \cdot T/(2 \cdot L) &= -0.9375 \\ Q_0 + \exp(B19) &= 3.52445064\end{aligned}$$

4 vertical alignments; 3 horizontal alignments

1 shared vertical alignment; 2 horizontal alignments

Alignment + contrast

Center + left is super common, but has weak contrast

Mixing left and right alignment provides stronger contrast

Chapter 1

Here's a title

Lorem ipsum dolor sit amet, consectetur adipisicing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua.

Chapter 1

Here's a title

Lorem ipsum dolor sit amet, consectetur adipisicing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua.

Proximity

Group related items together.

Proximity

Use white space, color, location, contrast, repetition, alignment, etc. to make visually distinct groupings

Ralph Roister Doister

(717) 555-1212

Mermaid Tavern

916 Bread Street

London, NM

Bad proximity; no logical groupings

Mermaid Tavern

Ralph Roister Doister

916 Bread Street
London, NM
(717) 555-1212

Good proximity; information visually grouped

CRAP review

Contrast

**Your Attitude
is Your Life**

Lessons from
raising three children
as a single mom

Robin Williams
October 9

Repetition

**Your Attitude
is Your Life**

Lessons from
raising three children
as a single mom

Robin Williams
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Alignment

**Your Attitude
is Your Life**

Lessons from
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October 9

Proximity

**Your Attitude
is Your Life**

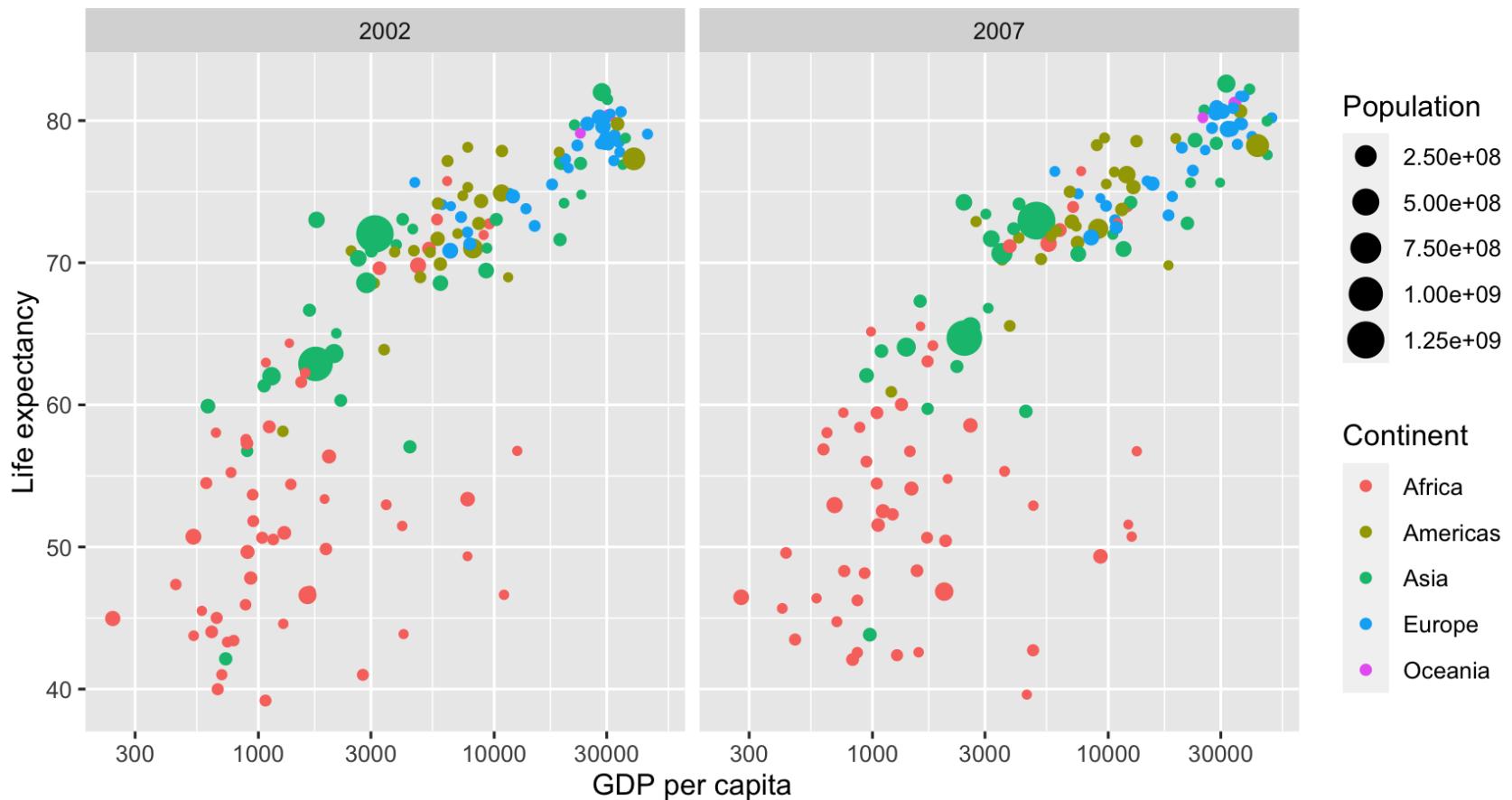
Lessons from
raising three children
as a single mom

Robin Williams
October 9

CRAP in action

Here's a cool title

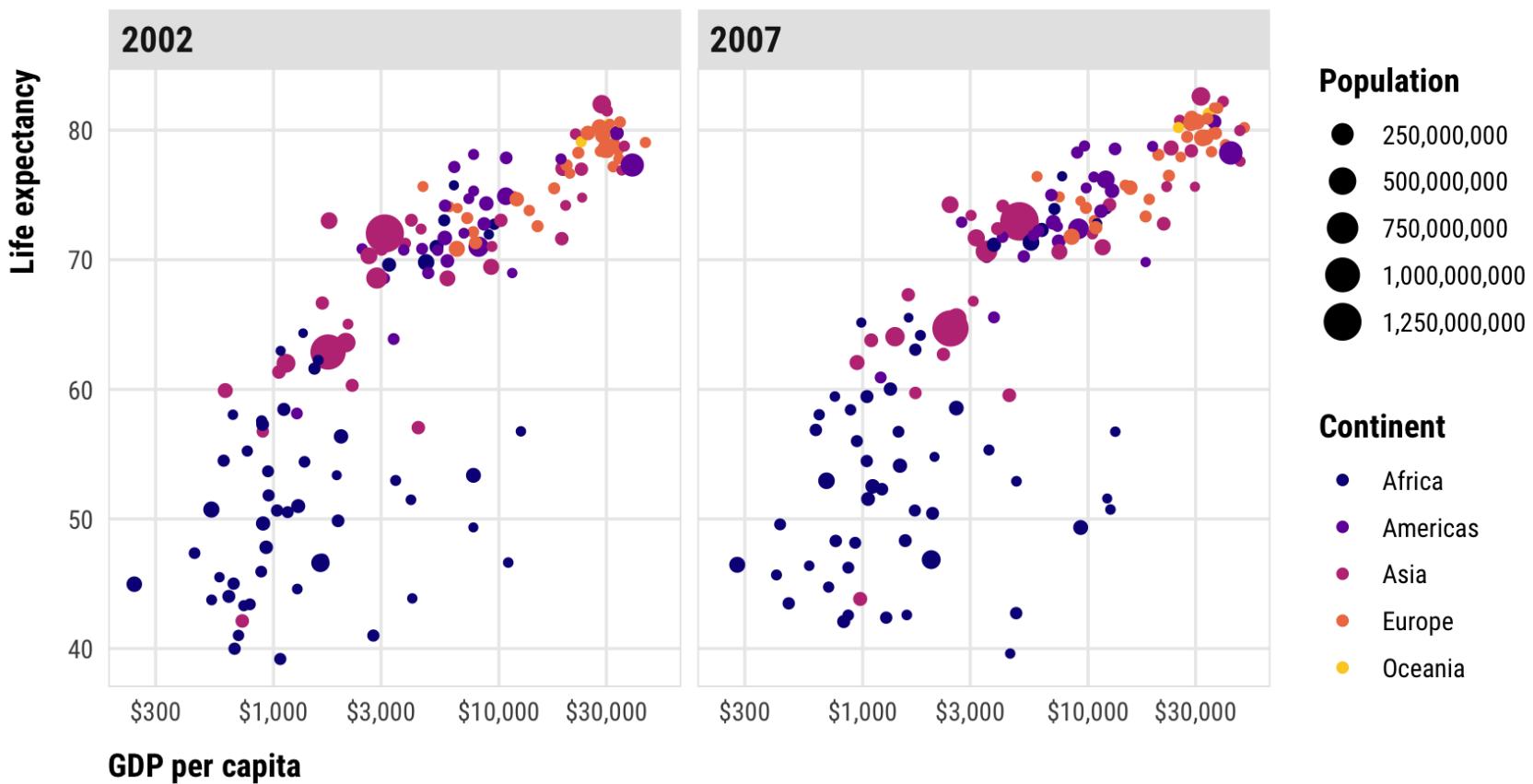
And here's a neat subtitle



CRAP in action

Here's a cool title

And here's a neat subtitle



Moral of the story

Moral of the story

Facts require beauty to be true

You can (and should) develop these skills!

Care about design.

andhs.co/umontreal-dataviz