

Visualization Analysis & Design

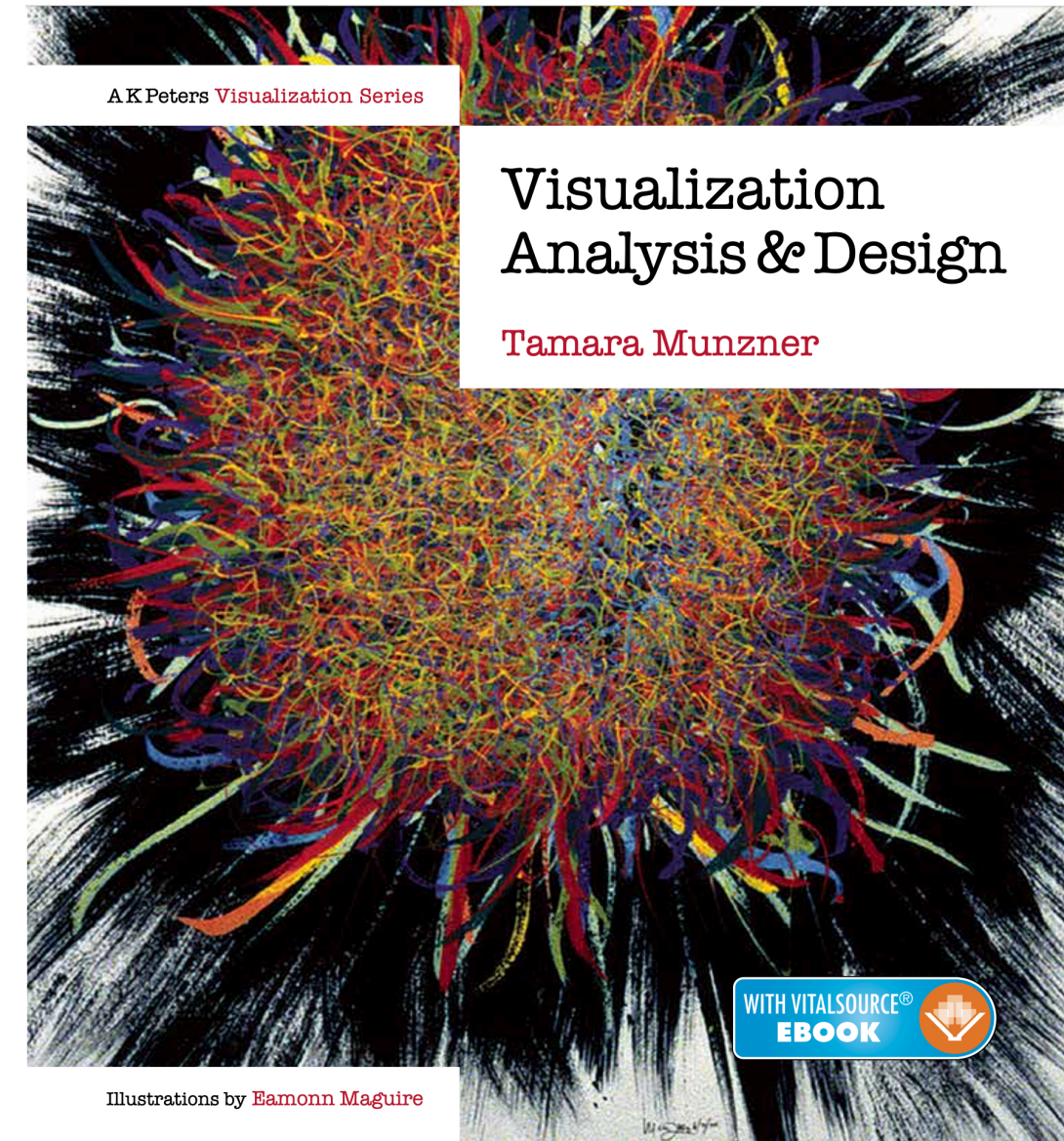
BMVC Tidbits

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UBC Biomedical Visualization and Communication
Oct 2025, virtual

<https://www.cs.ubc.ca/~tmm/talks.html#bmvc25>



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Defining visualization (vis)

Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively.

Why represent data visually?

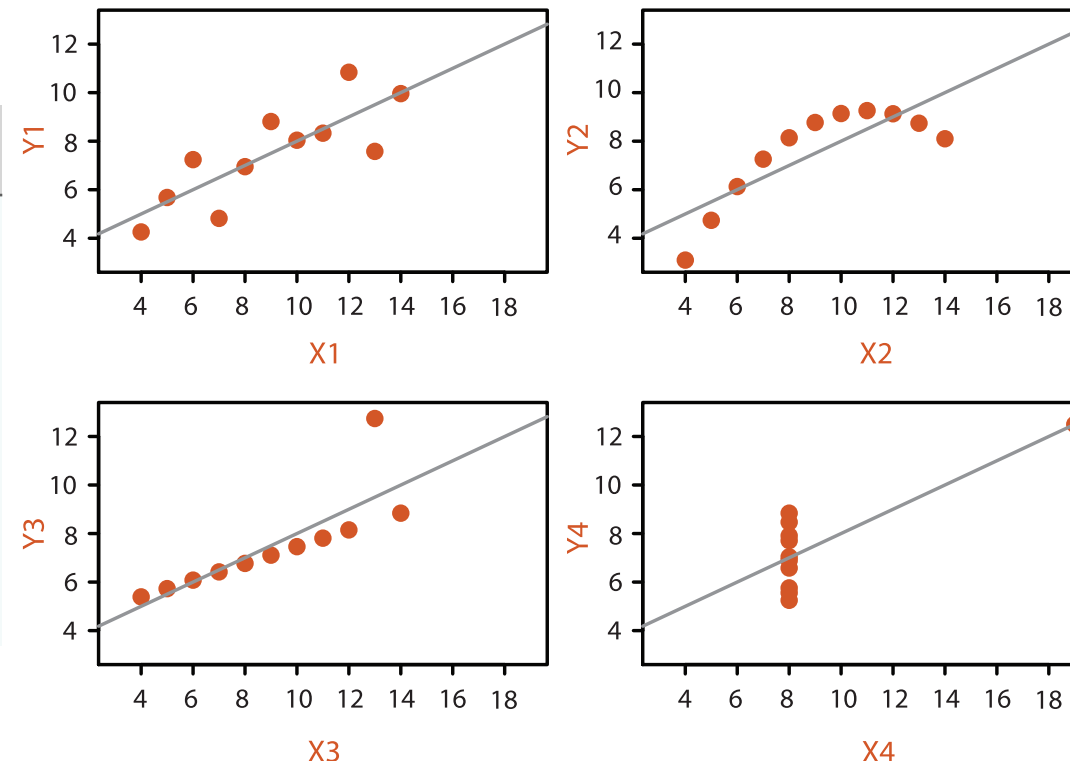
Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively:

- summaries lose information, details matter
 - confirm expected and find unexpected patterns
 - assess validity of statistical model

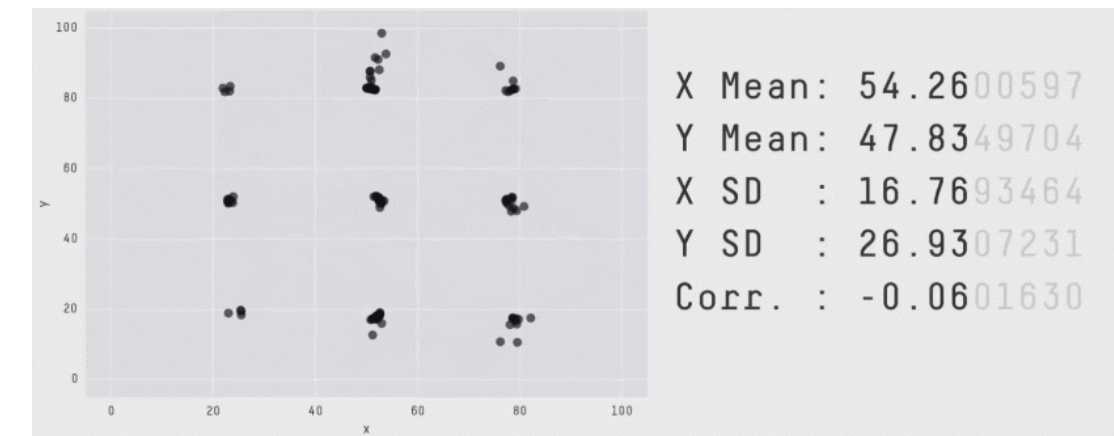
Anscombe's Quartet

Identical statistics

x mean	9
x variance	10
y mean	7.5
y variance	3.75
x/y correlation	0.816



Datasaurus Dozen



Same Stats, Different Graphs: Generating Datasets with Varied Appearance and Identical Statistics through Simulated Annealing. CHI 2017. Matejka & Fitzmaurice

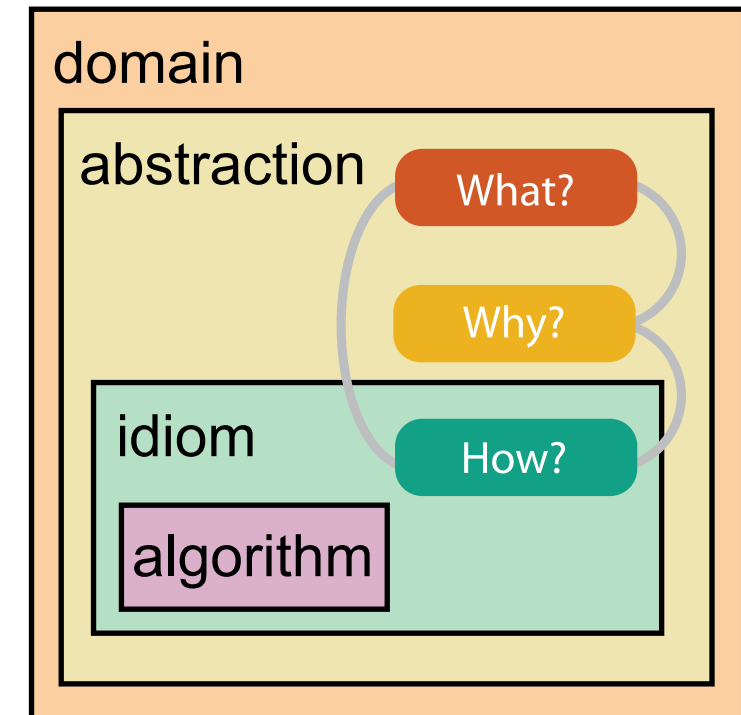
Visualization analysis framework: Four levels, three questions

- *domain situation*
 - who are the target users?

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- *domain situation*
 - who are the target users?
- *abstraction*
 - translate from specifics of domain to vocabulary of vis
 - **what** is shown? **data** abstraction
 - **why** is the user looking at it? **task** abstraction

[A Nested Model of Visualization Design and Validation.
Munzner. *IEEE TVCG* 15(6):921-928, 2009
(Proc. InfoVis 2009).]

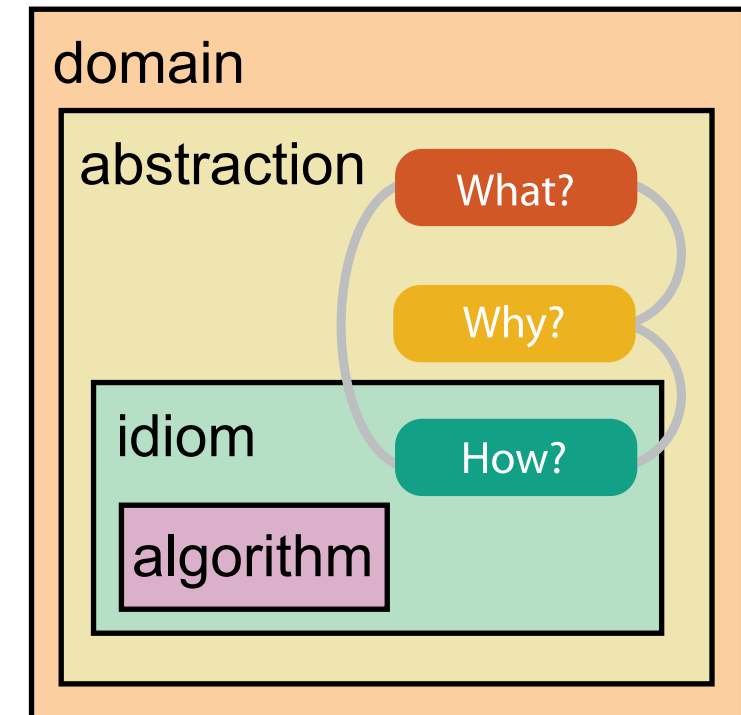


[A Multi-Level Typology of Abstract Visualization Tasks
Brehmer and Munzner. *IEEE TVCG* 19(12):2376-2385,
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- *idiom*
 - **how** is it shown?
 - **visual encoding** idiom: how to draw
 - **interaction** idiom: how to manipulate

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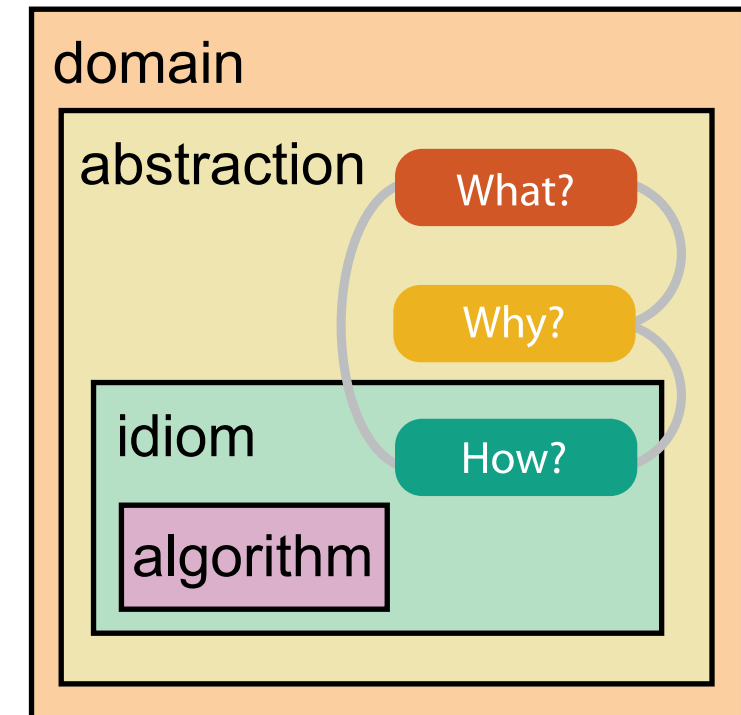


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 - **interaction** idiom: how to manipulate
- *algorithm*
 - efficient computation

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Why is validation difficult?

- different ways to get it wrong at each level



Domain situation

You misunderstood their needs



Data/task abstraction

You're showing them the wrong thing



Visual encoding/interaction idiom

The way you show it doesn't work

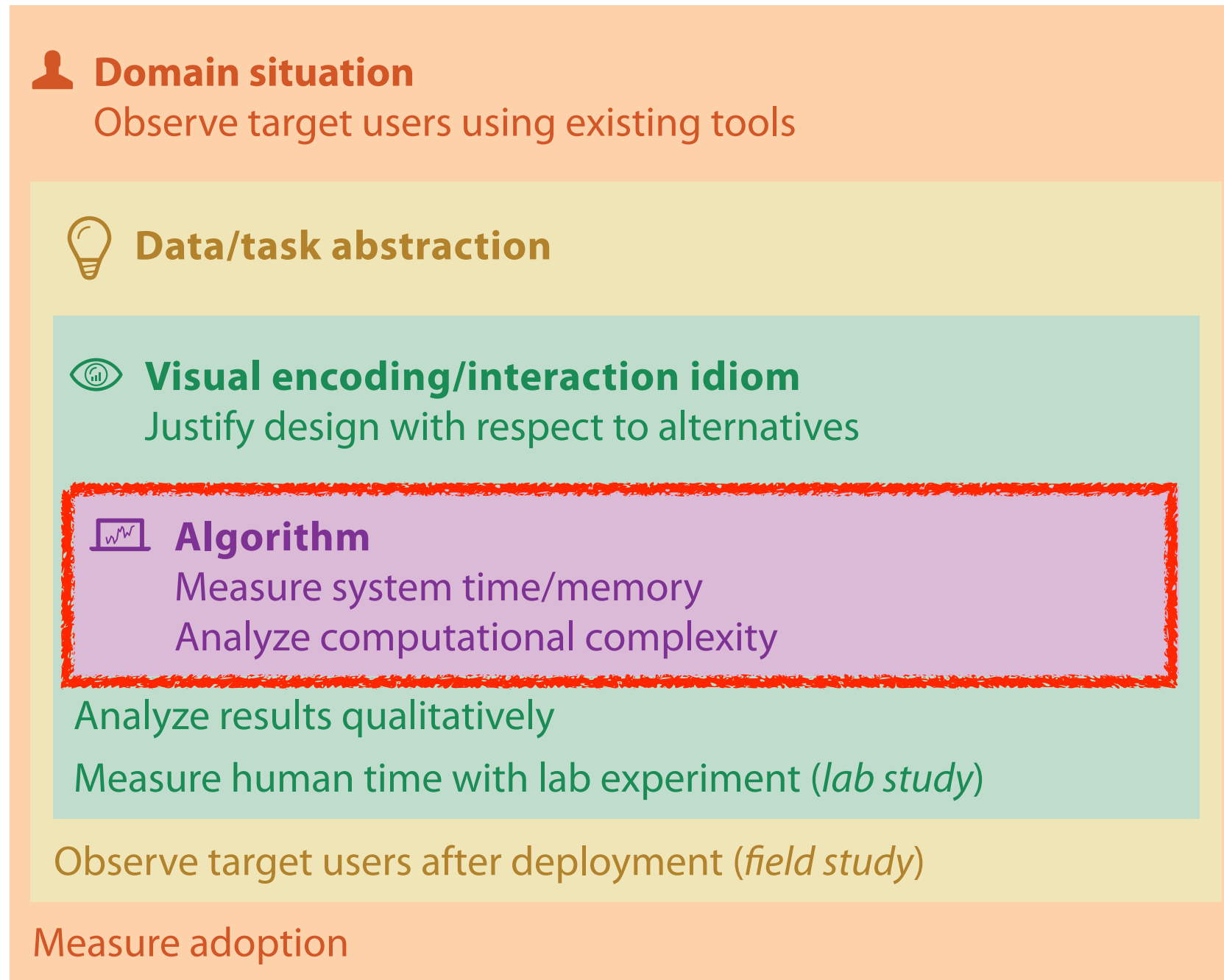


Algorithm

Your code is too slow

Why is validation difficult?

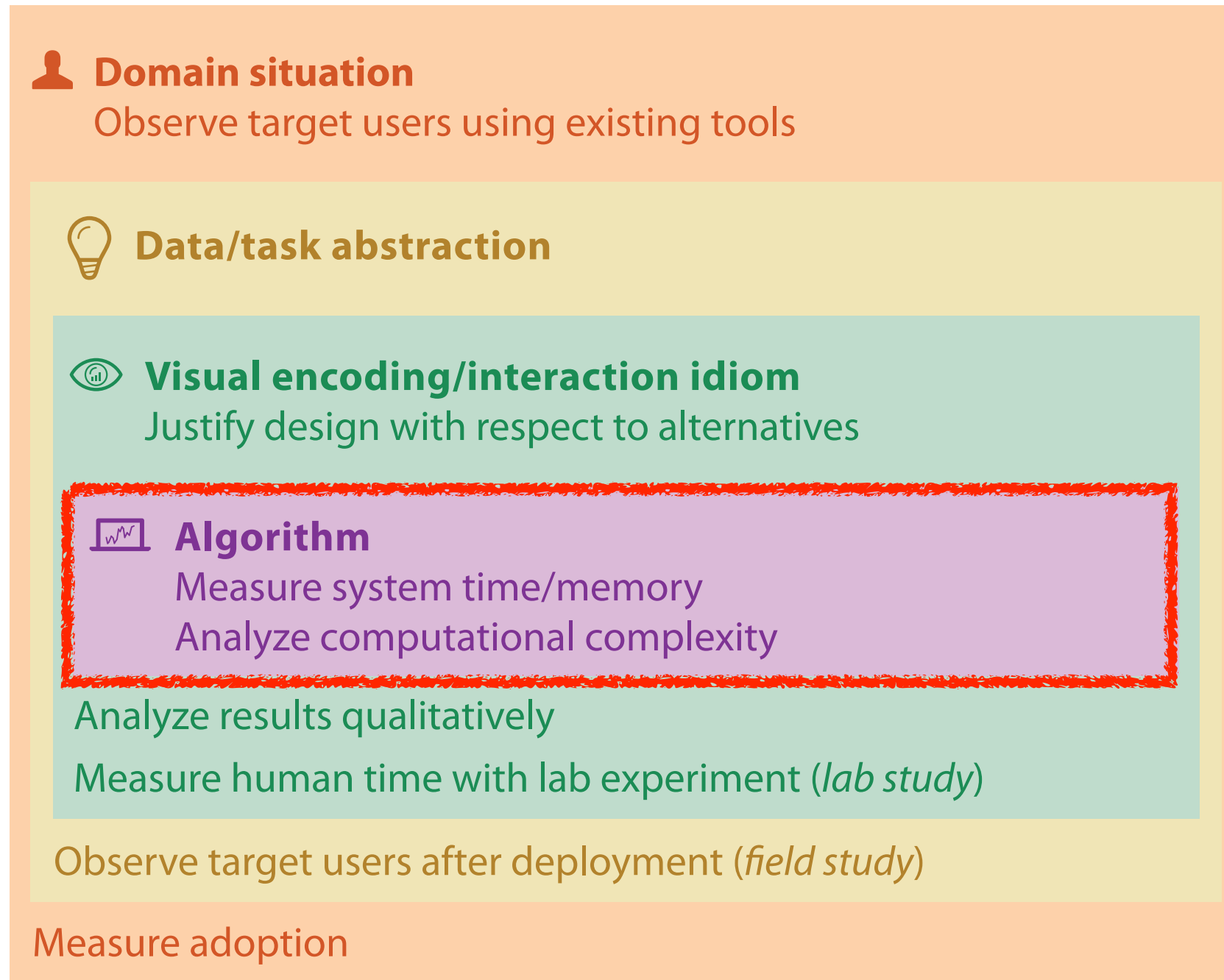
- solution: use methods from different fields at each level



Why is validation difficult?

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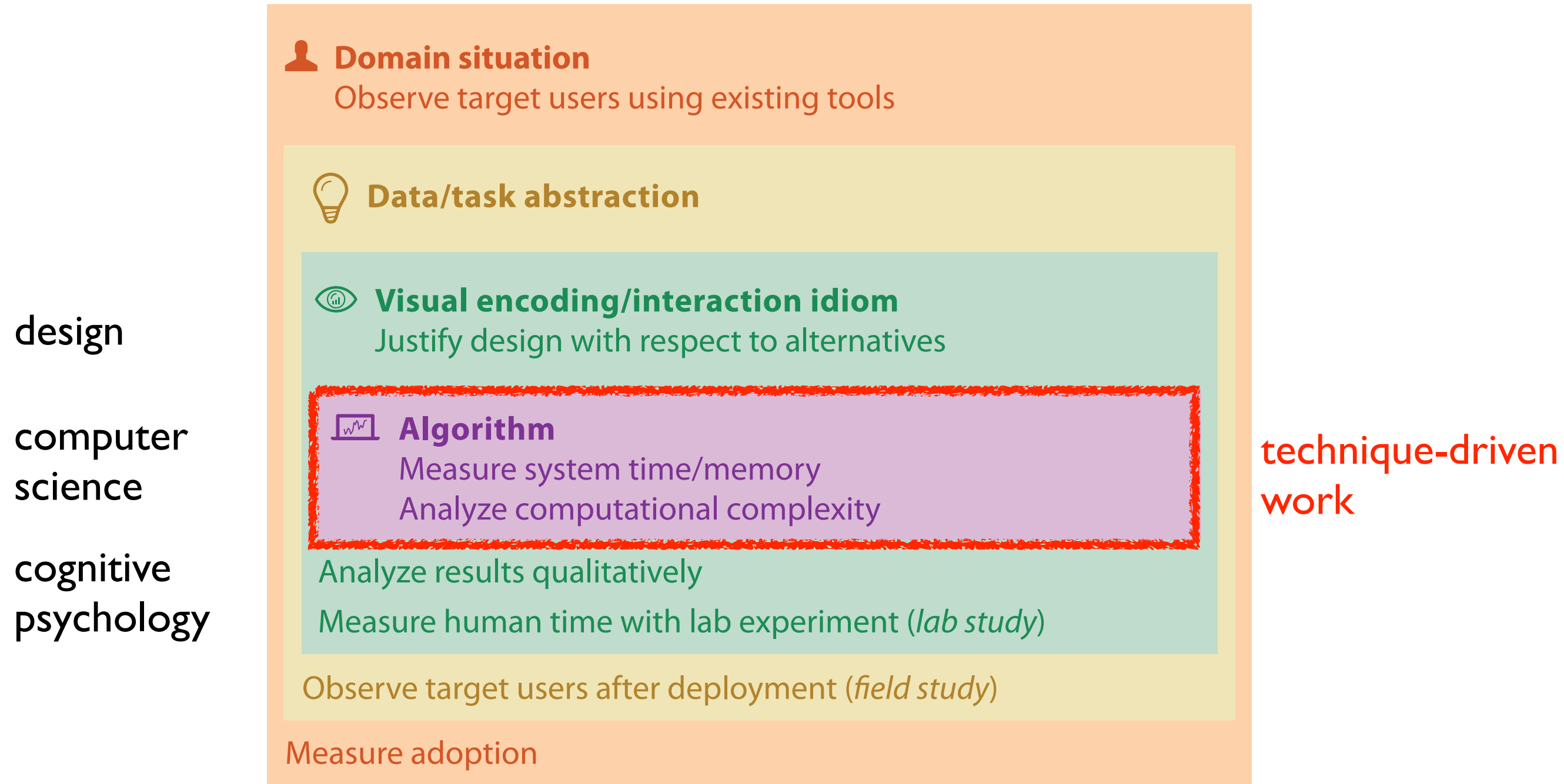
computer
science



technique-driven
work

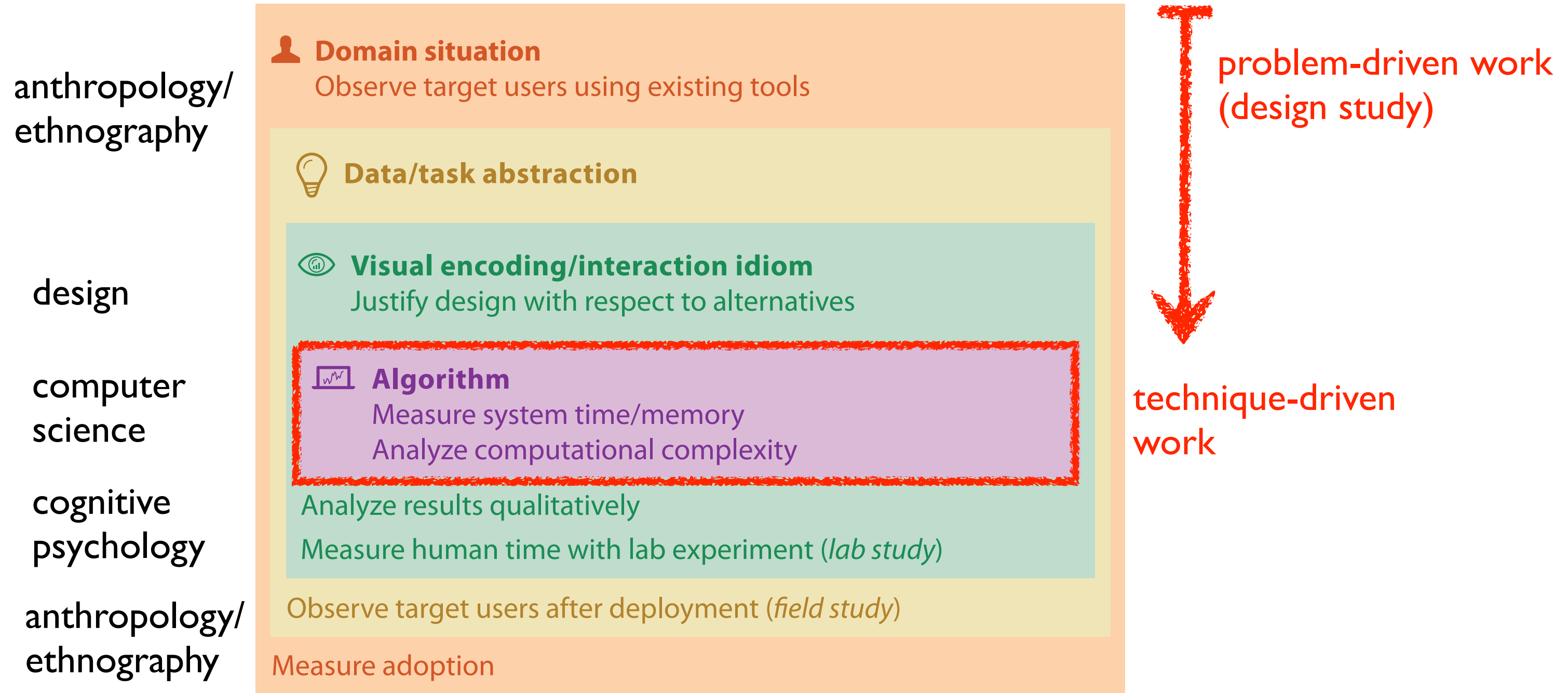
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Why is validation difficult?

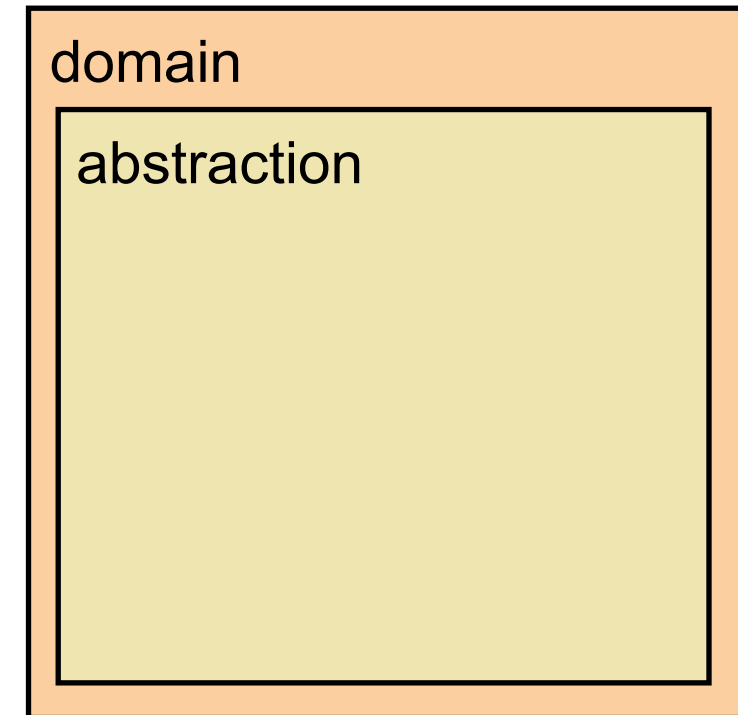
- solution: use methods from different fields at each level



Abstractions

Abstraction: Data & task

- map *what* and *why* into generalized terms
 - identify tasks that users wish to perform, or already do
 - find data types that will support those tasks
 - possibly transform /derive if need be



Example: Find good movies

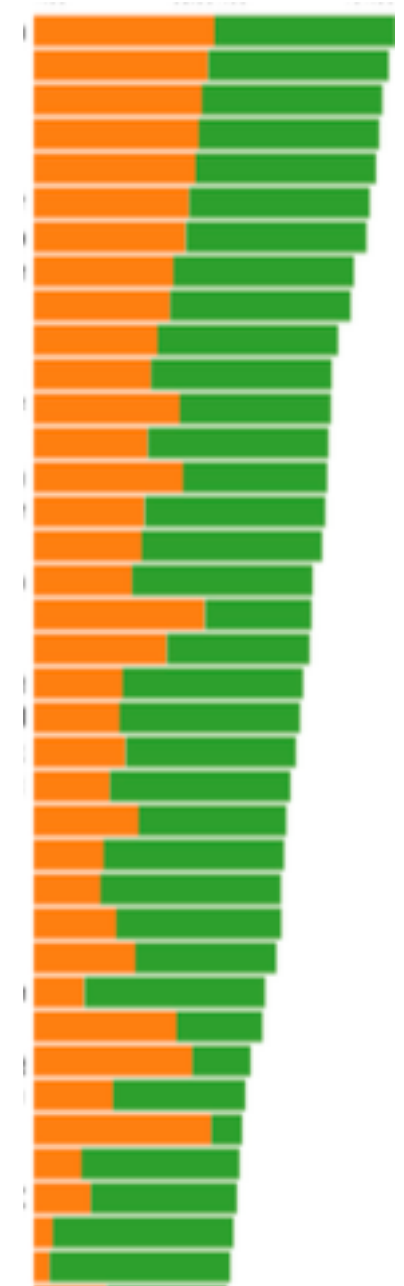
- identify good movies in genres I like
- domain:
 - general population, movie enthusiasts
- task: what is a good movie for me?
 - highly rated by critics?
 - highly rated by audiences?
 - successful at the box office?
 - similar to movies I liked?
 - matches specific genres?
- data: (is it available?)
 - yes! data sources IMDB, Rotten Tomatoes...

Example: Find good movies

- one possible choice for data and tasks, in domain language
 - data: combine audience ratings and critic ratings
 - task: find high-scoring movies for specific genre
- abstractions?
 - attribute: audience & critic ratings
 - ordinal
 - levels: 3 or 5 or 10...
 - attribute: genre
 - categorical
 - levels: < 20
 - items: movies
 - items: millions
 - task: find extreme (high) values

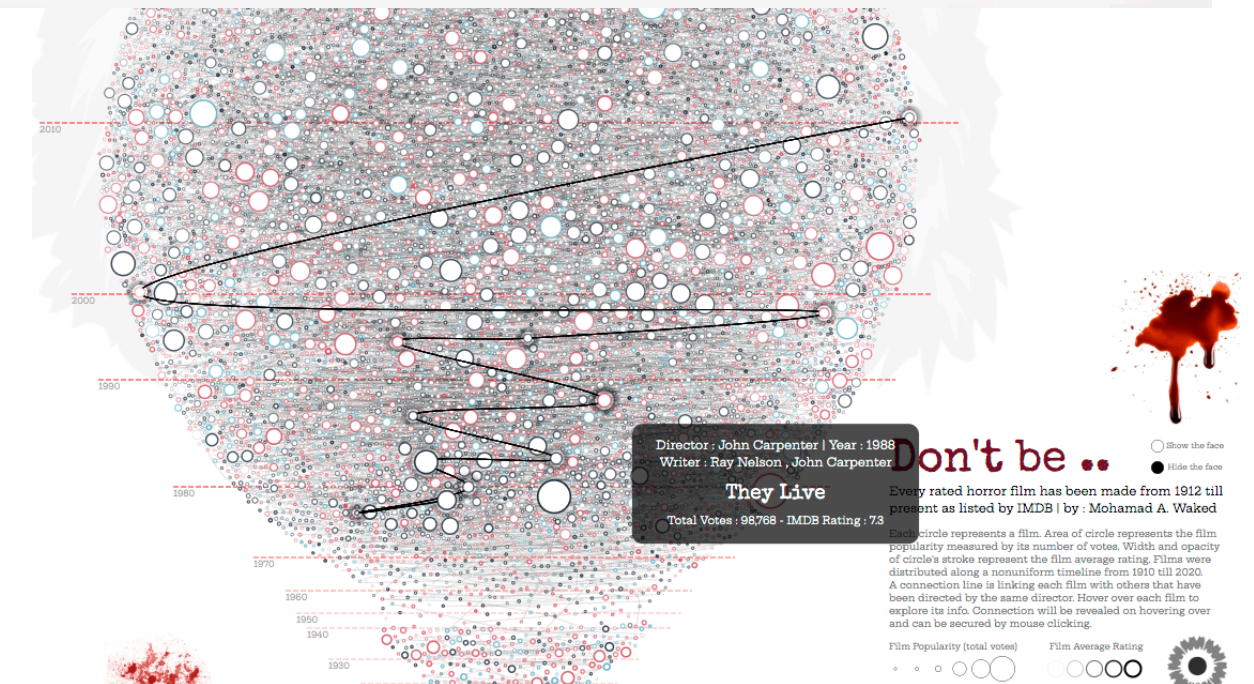
one possible idiom

- stacked bar chart for ratings



Example: Horrified

- same task: high-score movies
- slightly different data
 - 14K rated horror movies from IMDB

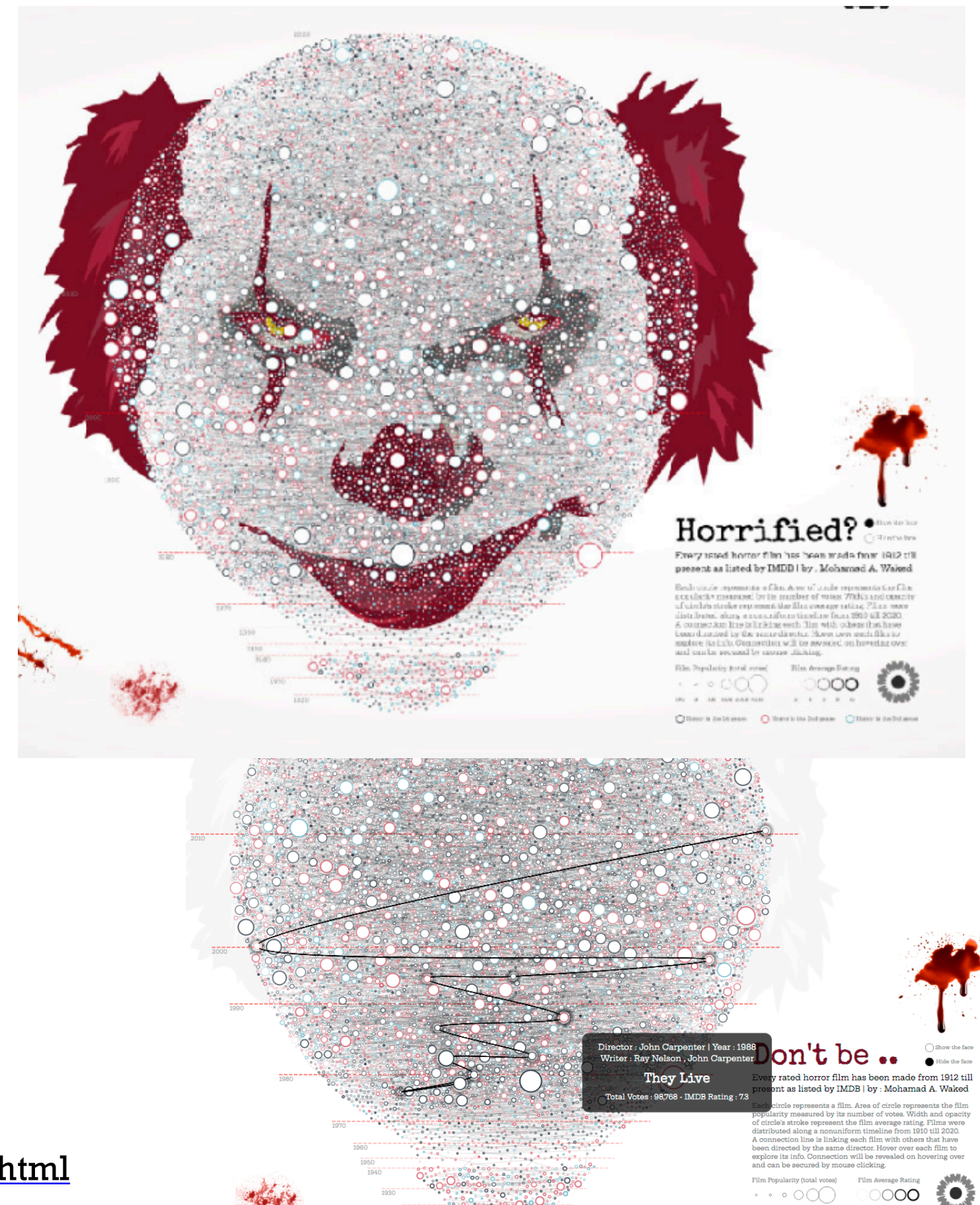


<https://www.alhadaqa.com/wp-content/uploads/2020/04/horrified.html>

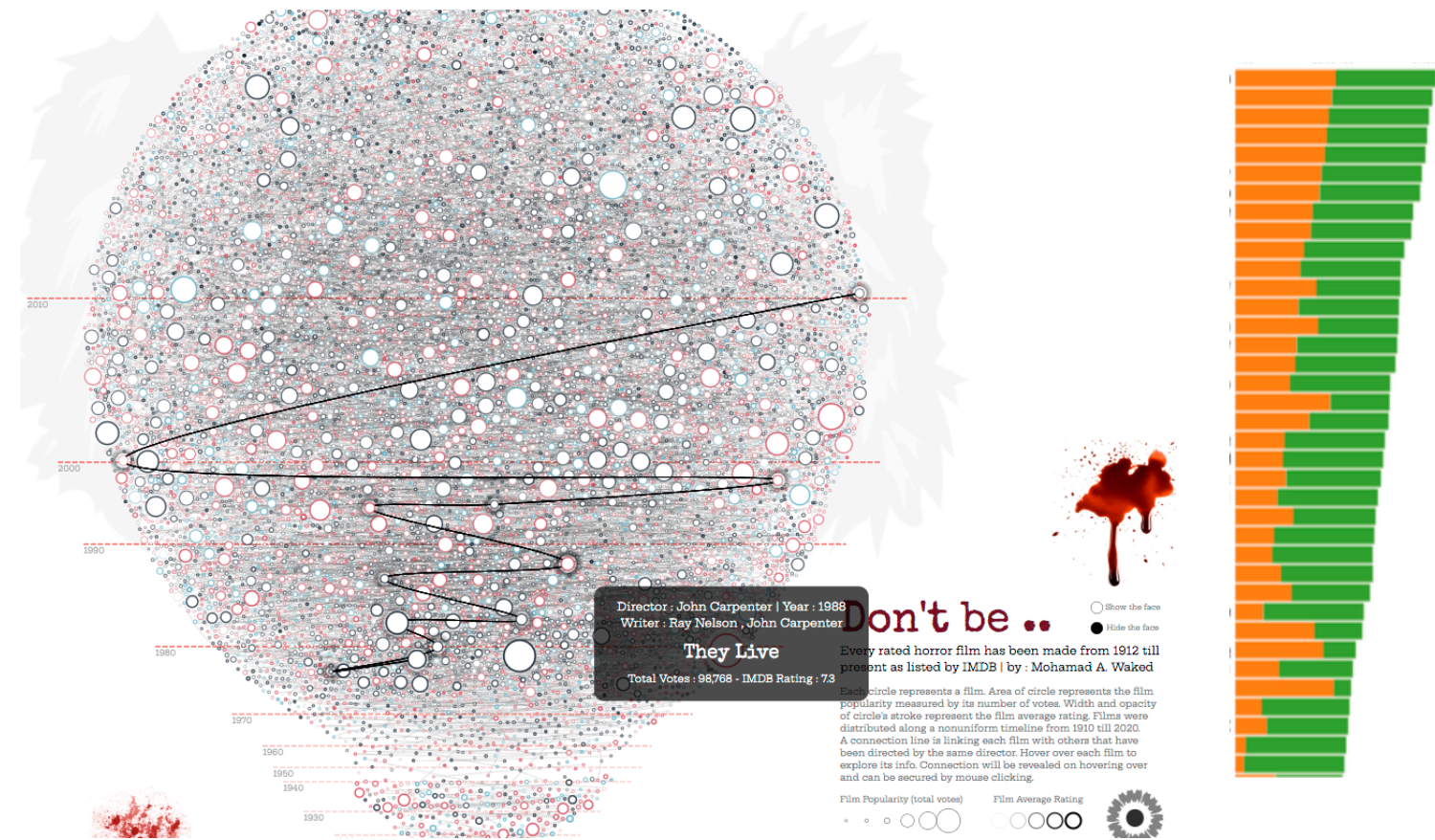
Example: Horrified

- same task: high-score movies
- slightly different data
 - 14K rated horror movies from IMDB
- very different visual encoding idiom
 - circle per item (movie)
 - circle area = popularity
 - stroke width/opacity = avg rating
 - year made = vertical position
- interaction idiom
 - lines connect movies w/ same director, on mouseover

<https://www.alhadaqa.com/wp-content/uploads/2020/04/horrified.html>



- horrified: browse/explore
- stacked bars: locate/lookup
- which is better?
 - depends on goals / task
 - enjoy, social context, lots of time
 - find 2nd-best rated movie of all time
 - Jeopardy call, < 10 seconds to respond!

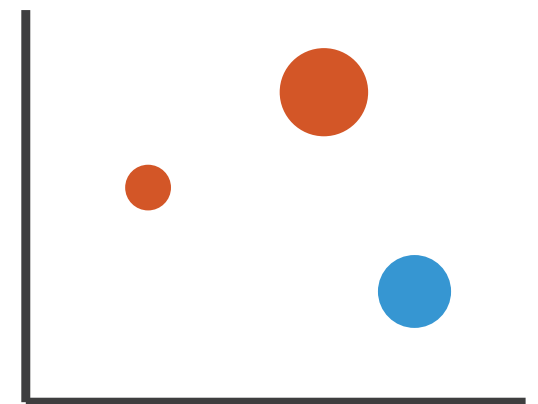
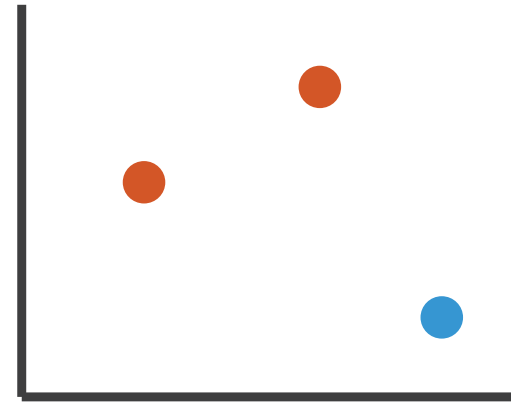
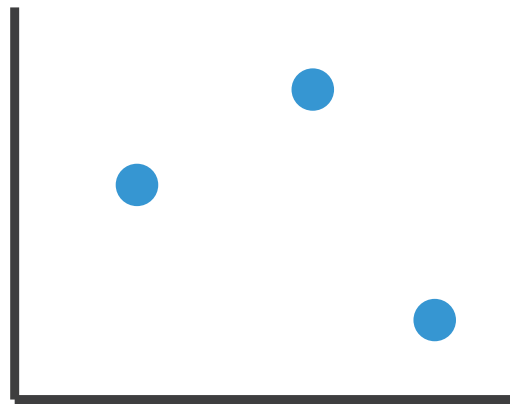
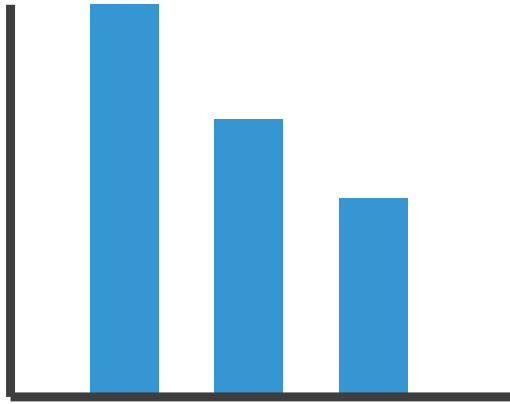


<http://alhadaga.com/2019/10/horrified/>

Visual Encoding Idioms

Visual encoding

- analyze idiom structure



Definitions: Marks and channels

Definitions: Marks and channels

- marks
 - geometric primitives

→ Points



→ Lines



→ Areas



Definitions: Marks and channels

- marks
 - geometric primitives
- channels
 - control appearance of marks

→ Points



→ Lines



→ Areas



→ Position

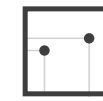
→ Horizontal



→ Vertical



→ Both



→ Color



→ Shape



→ Tilt



→ Size

→ Length



→ Area

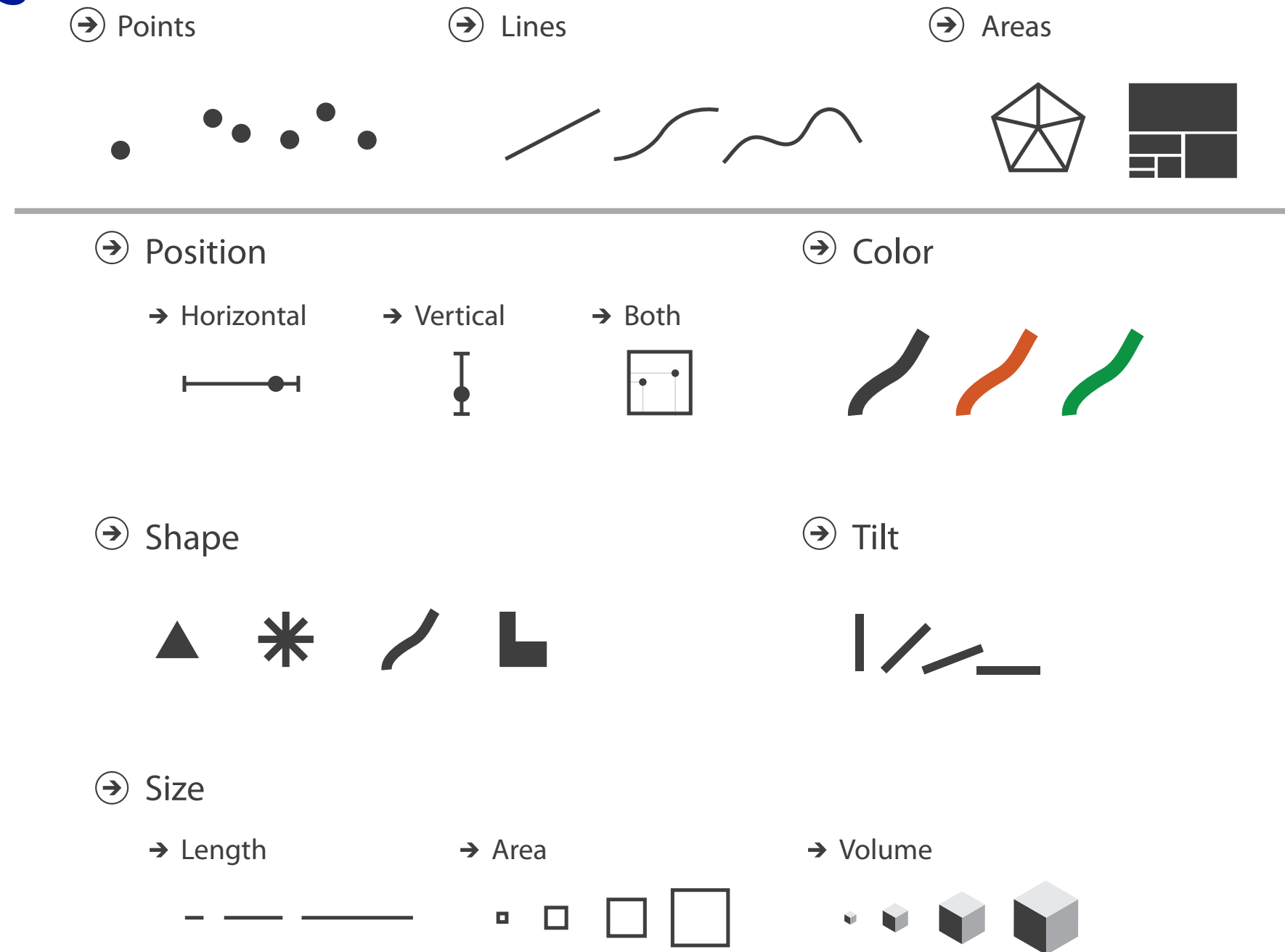


→ Volume



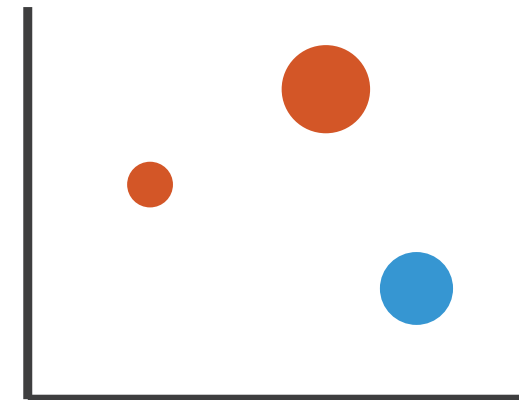
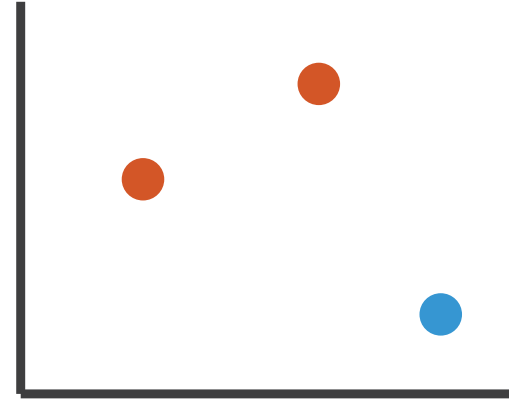
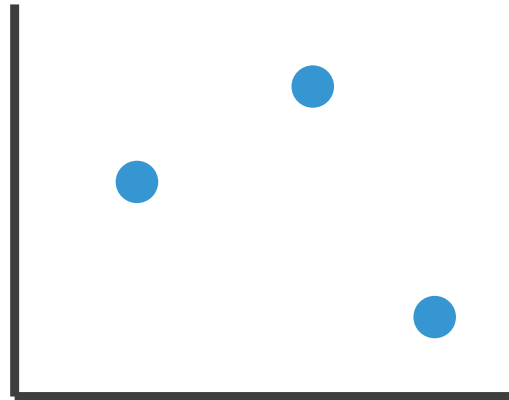
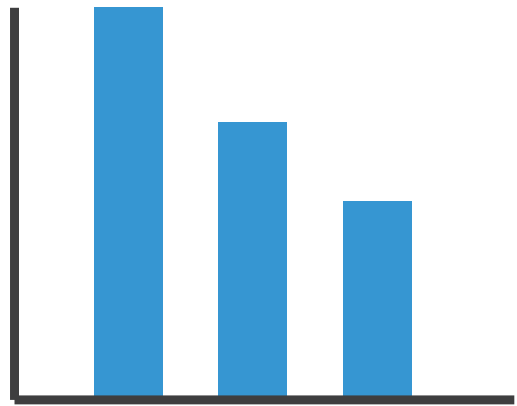
Definitions: Marks and channels

- marks
 - geometric primitives
- channels
 - control appearance of marks
- channel properties differ
 - type & amount of information that can be conveyed to human perceptual system



Visual encoding

- analyze idiom structure as combination of marks and channels

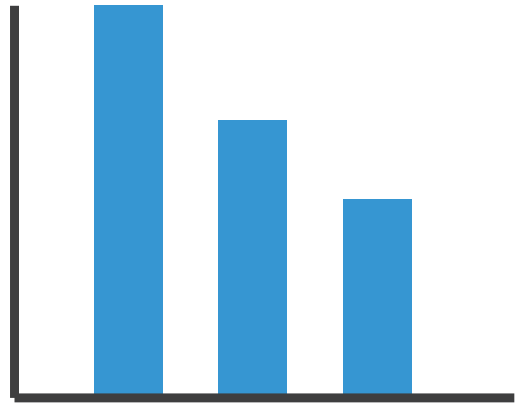


1:
vertical position

mark: line

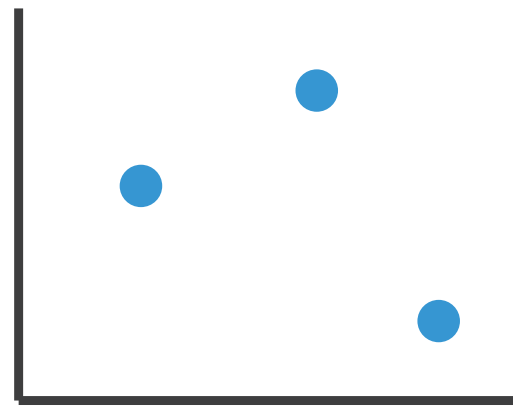
Visual encoding

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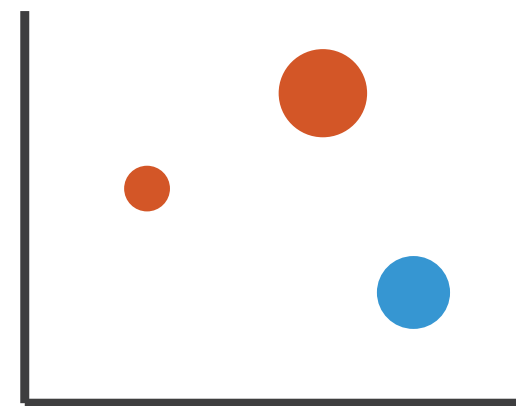
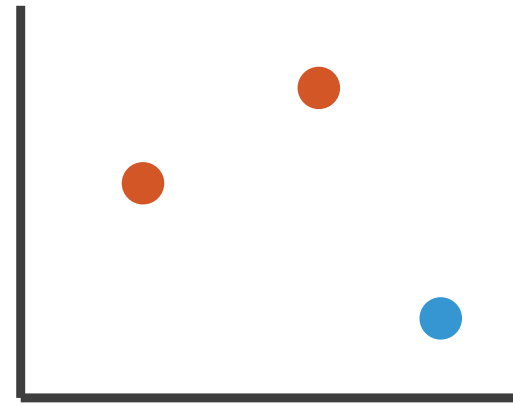
1:
vertical position

mark: line



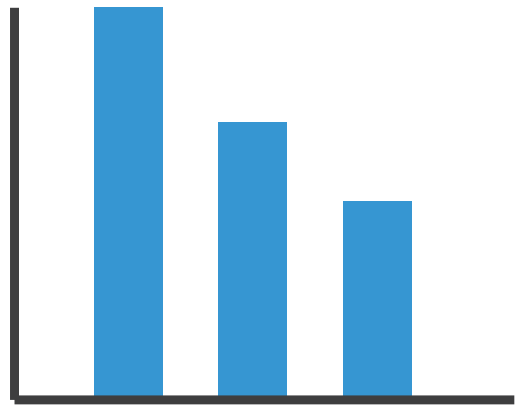
2:
vertical position
horizontal position

mark: point



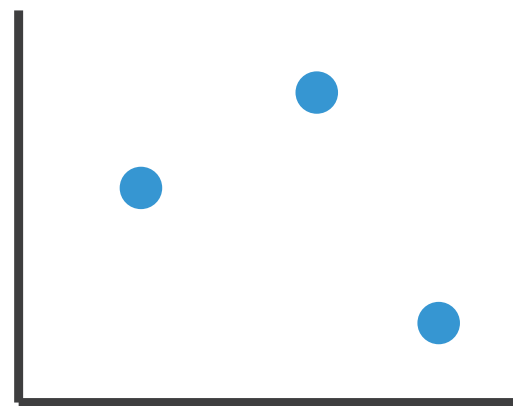
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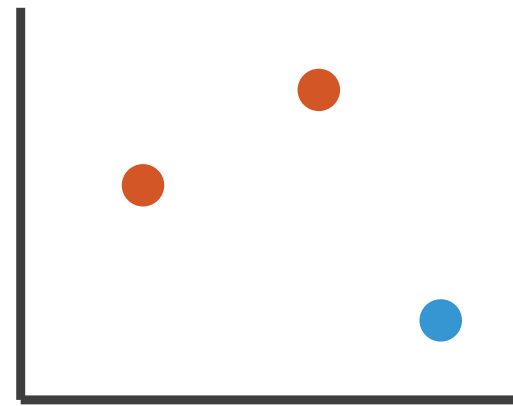
1:
vertical position

mark: line



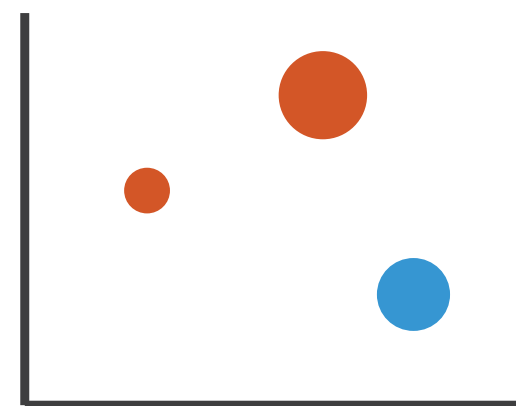
2:
vertical position
horizontal position

mark: point



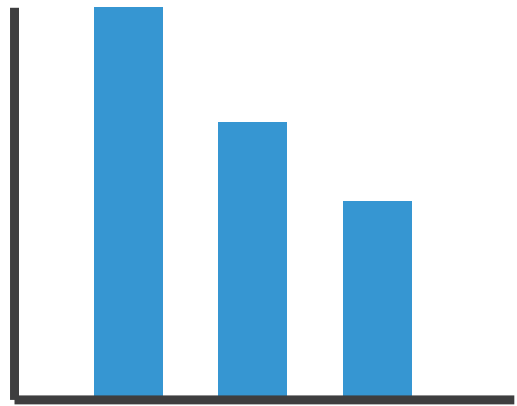
3:
vertical position
horizontal position
color hue

mark: point



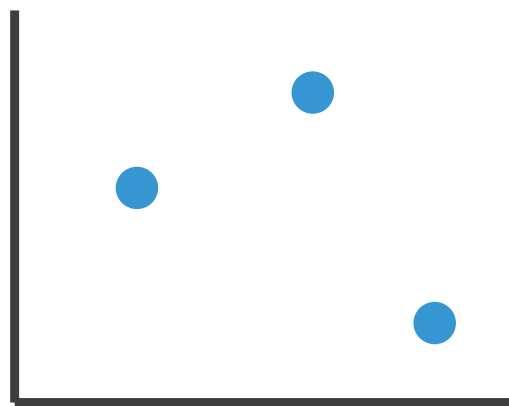
Visual encoding

- analyze idiom structure as combination of marks and channels



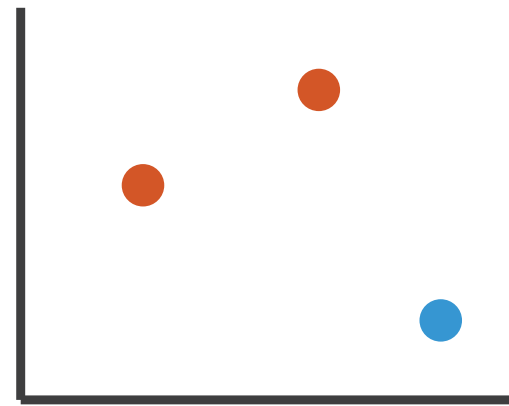
1:
vertical position

mark: line



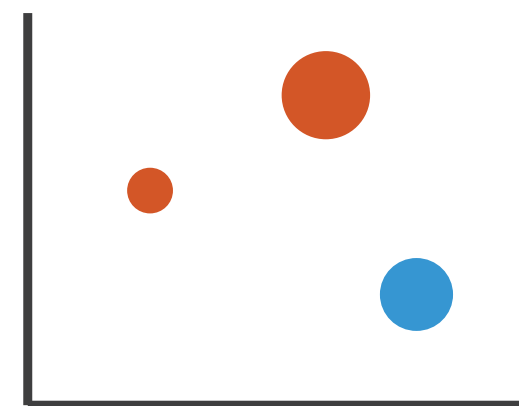
2:
vertical position
horizontal position

mark: point



3:
vertical position
horizontal position
color hue

mark: point



4:
vertical position
horizontal position
color hue
size (area)

mark: point

Channels: Rankings

Position on common scale



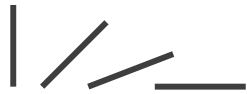
Position on unaligned scale



Length (1D size)



Tilt/angle



Area (2D size)



Depth (3D position)



Color luminance



Color saturation



Curvature



Volume (3D size)



Same

Spatial region



Color hue



Motion



Shape



Channels: Rankings

➔ **Magnitude** Channels: **Ordered** Attributes

Position on common scale



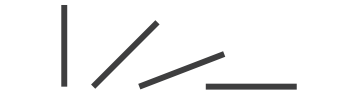
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Color luminance



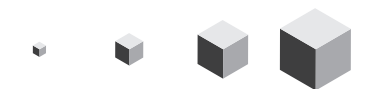
Color saturation



Curvature



Volume (3D size)



Same

Same

➔ **Identity** Channels: **Categorical** Attributes

Spatial region



Color hue



Motion



Shape



- **expressiveness**
 - match channel and data characteristics

Channels: Rankings

➔ **Magnitude** Channels: **Ordered** Attributes

Position on common scale



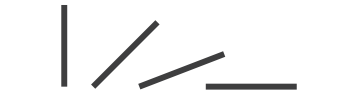
Position on unaligned scale



Length (1D size)



Tilt/angle



Area (2D size)



Depth (3D position)



Color luminance



Color saturation



Curvature



Volume (3D size)



Same
Same

➔ **Identity** Channels: **Categorical** Attributes

Spatial region



Color hue



Motion



Shape



➔ **Attribute Types**

➔ Categorical



➔ Ordered

➔ Ordinal



➔ Quantitative



- **expressiveness**

- match channel and data characteristics

- magnitude for ordered

- how much? which rank?

- identity for categorical

- what?

Channels: Rankings

➔ **Magnitude** Channels: **Ordered** Attributes



➔ **Identity** Channels: **Categorical** Attributes



- **expressiveness**
 - match channel and data characteristics
- **effectiveness**
 - channels differ in accuracy of perception

Channels: Rankings

➔ Magnitude Channels: Ordered Attributes

Position on common scale



Position on unaligned scale



Length (1D size)



Tilt/angle



Area (2D size)



Depth (3D position)



Color luminance



Color saturation



Curvature



Volume (3D size)



Best ▲

Effectiveness

▼ Least

➔ Identity Channels: Categorical Attributes

Spatial region



Color hue



Motion



Shape

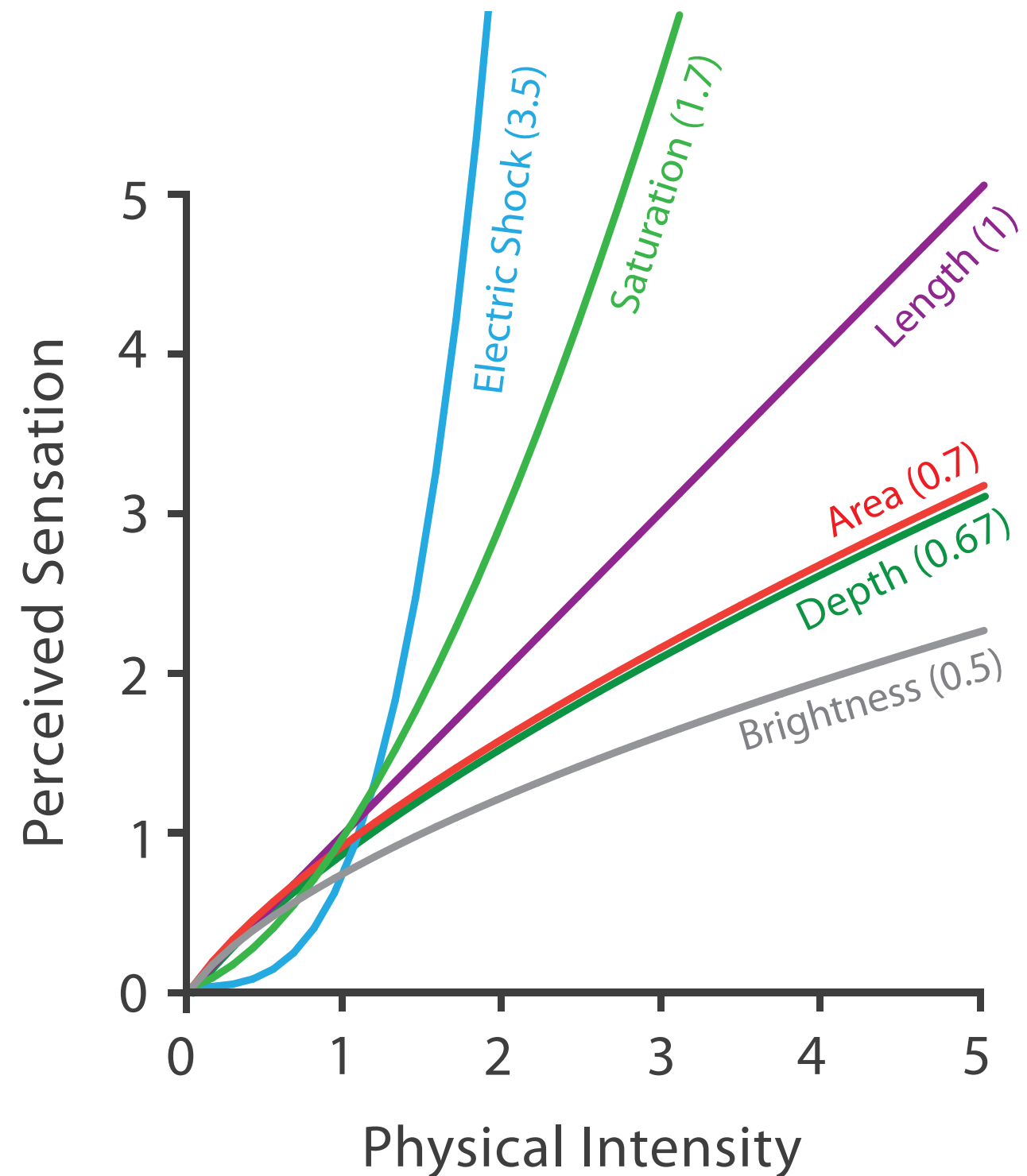


- **expressiveness**
 - match channel and data characteristics
- **effectiveness**
 - channels differ in accuracy of perception
 - spatial position ranks high for both

Accuracy: Fundamental theory

- length is accurate: linear
- others magnified or compressed
 - exponent characterizes

Steven's Psychophysical Power Law: $S = I^N$

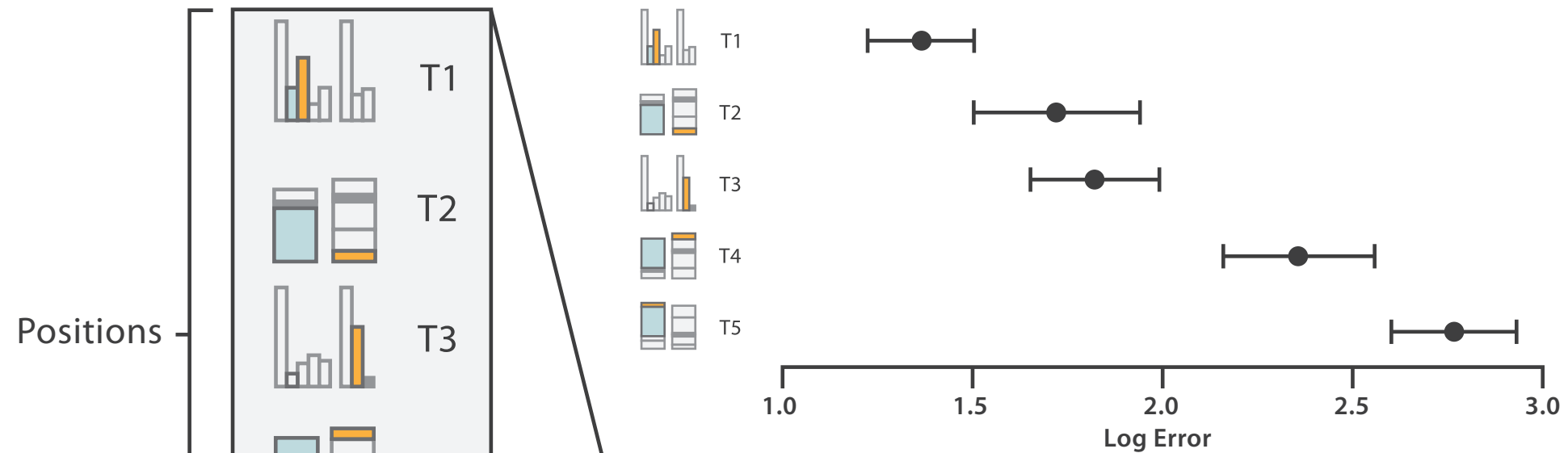


S = sensation

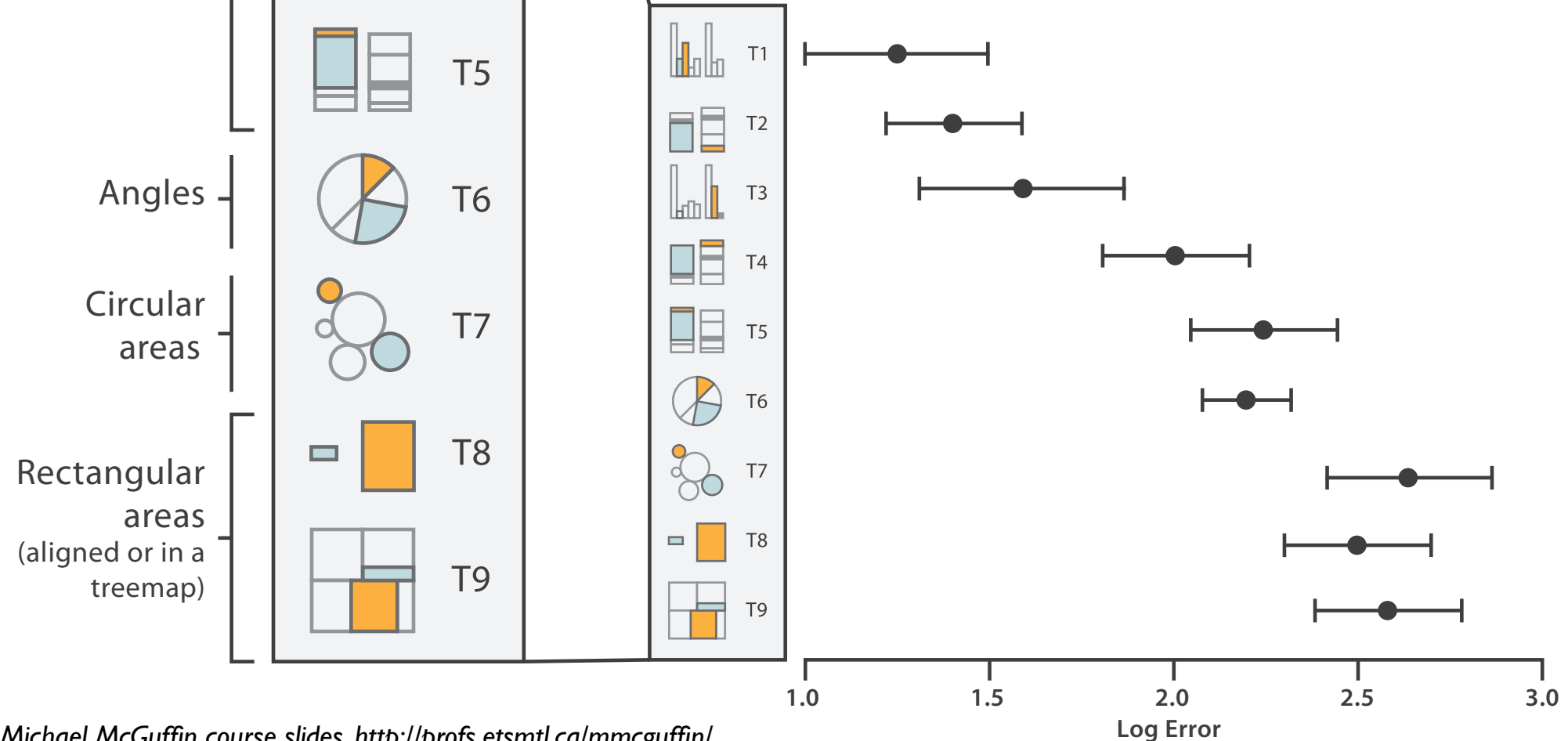
I = intensity

Accuracy: Vis experiments

Cleveland & McGill's Results



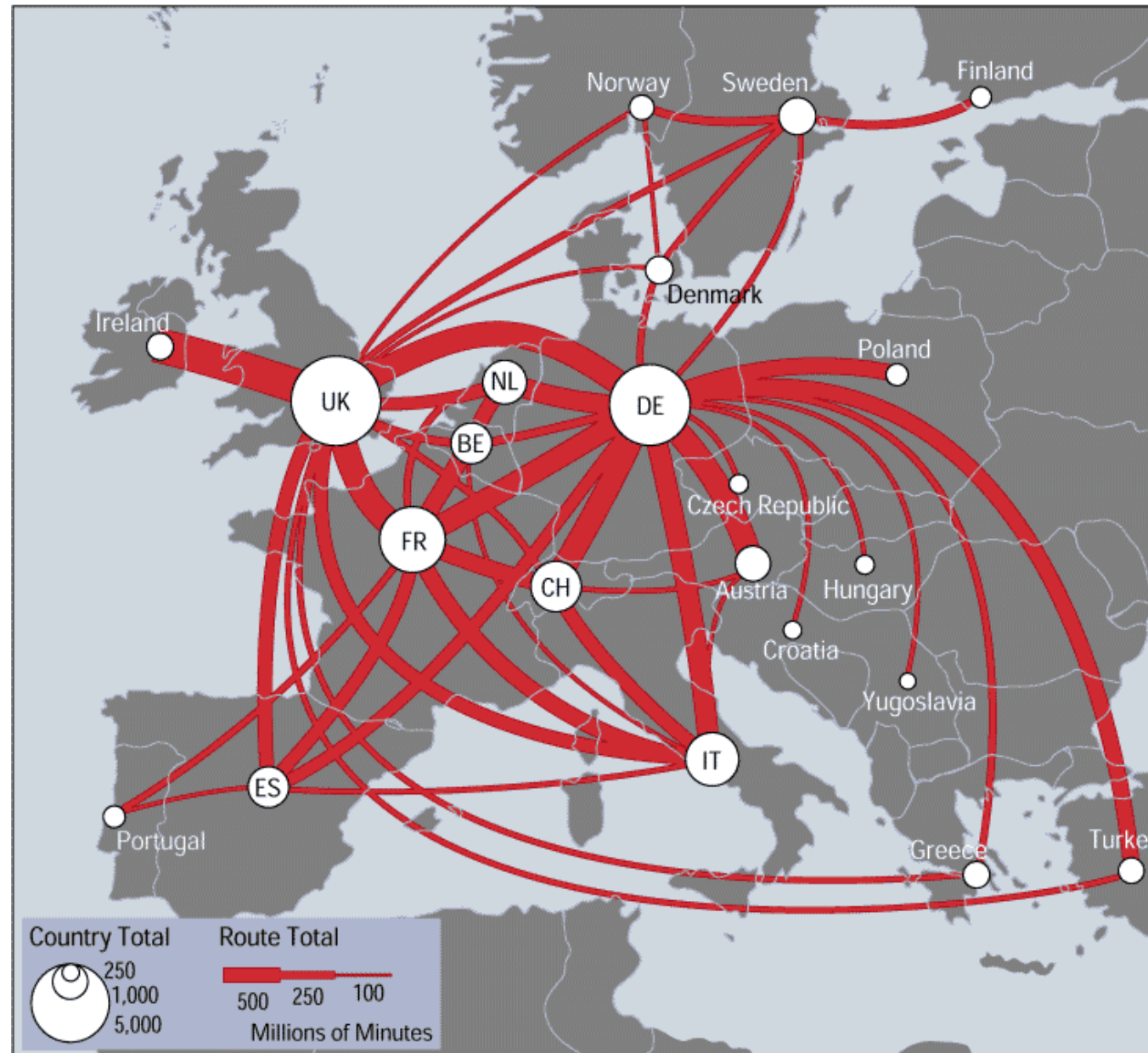
Crowdsourced Results



[Crowdsourcing Graphical Perception: Using Mechanical Turk to Assess Visualization Design. Heer and Bostock. Proc ACM Conf. Human Factors in Computing Systems (CHI) 2010, p. 203–212.]

Discriminability: How many usable steps?

- must be sufficient for number of attribute levels to show
 - linewidth: few bins



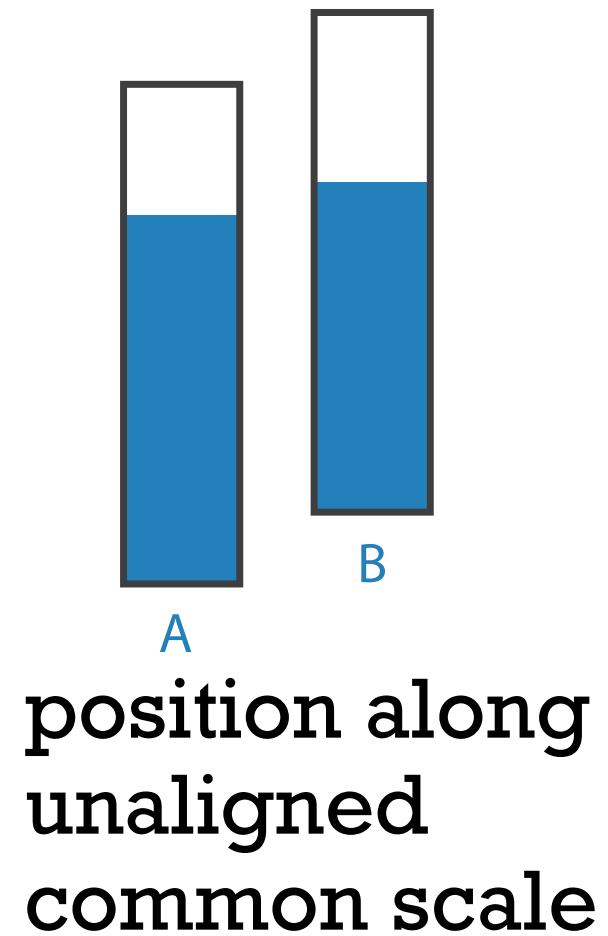
[mappa.mundi.net/maps/maps_014/telegeography.html]

Relative vs. absolute judgements

- perceptual system mostly operates with relative judgements, not absolute

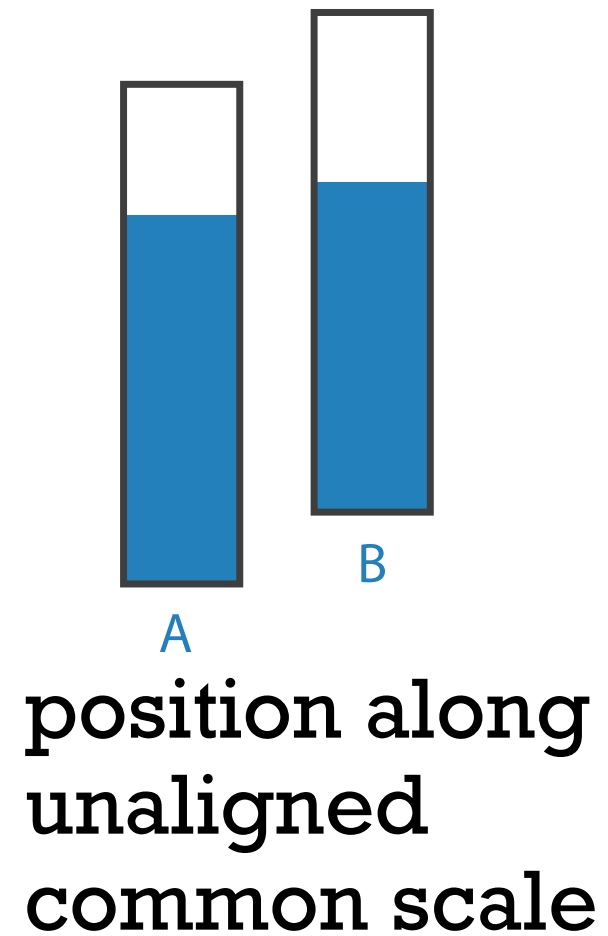
Relative vs. absolute judgements

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 - that's why accuracy increases with common frame/scale and alignment



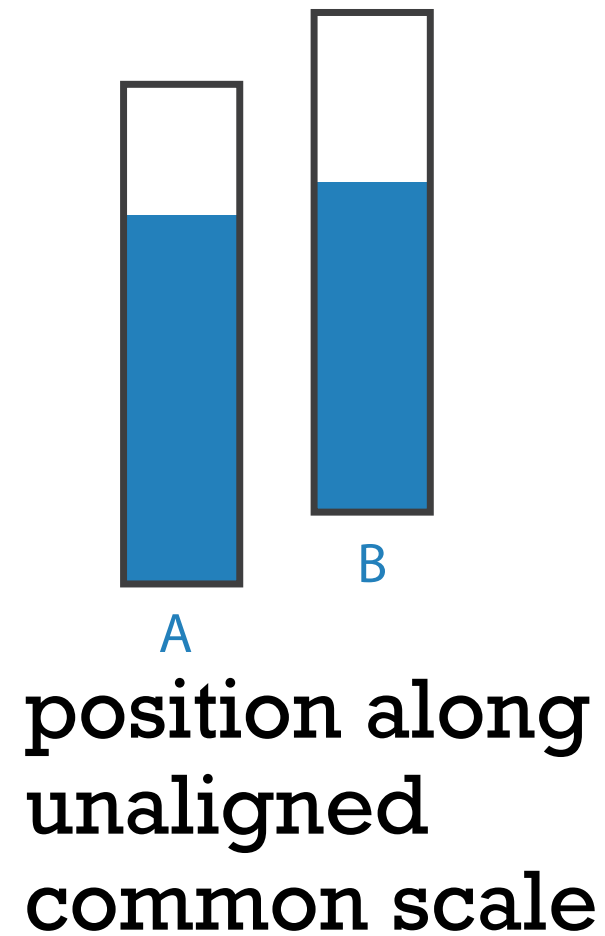
Relative vs. absolute judgements

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 - Weber's Law: ratio of increment to background is constant



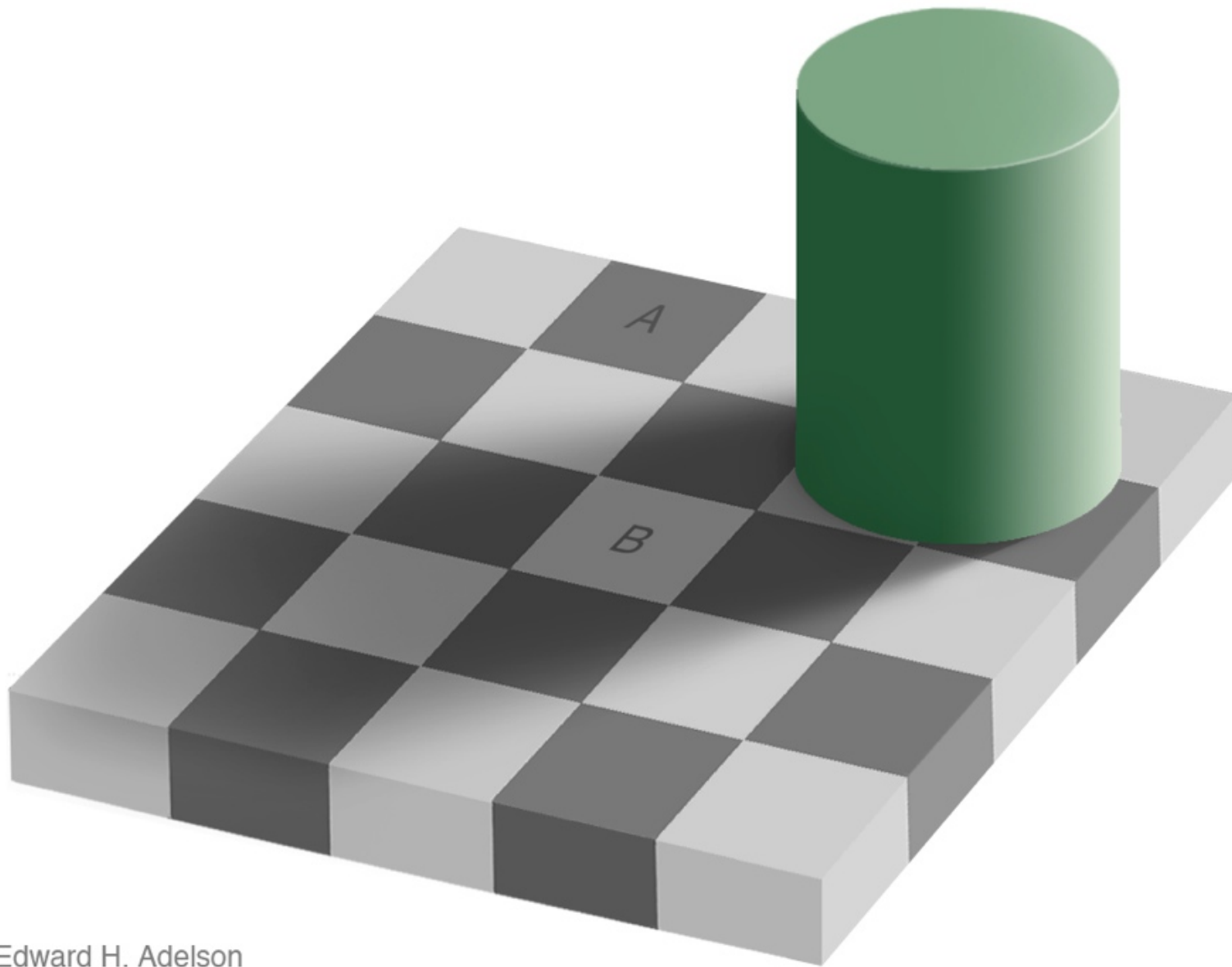
Relative vs. absolute judgements

- perceptual system mostly operates with relative judgements, not absolute
 - that's why accuracy increases with common frame/scale and alignment
 - Weber's Law: ratio of increment to background is constant
 - filled rectangles differ in length by 1:9, difficult judgement
 - white rectangles differ in length by 1:2, easy judgement



Relative luminance judgements

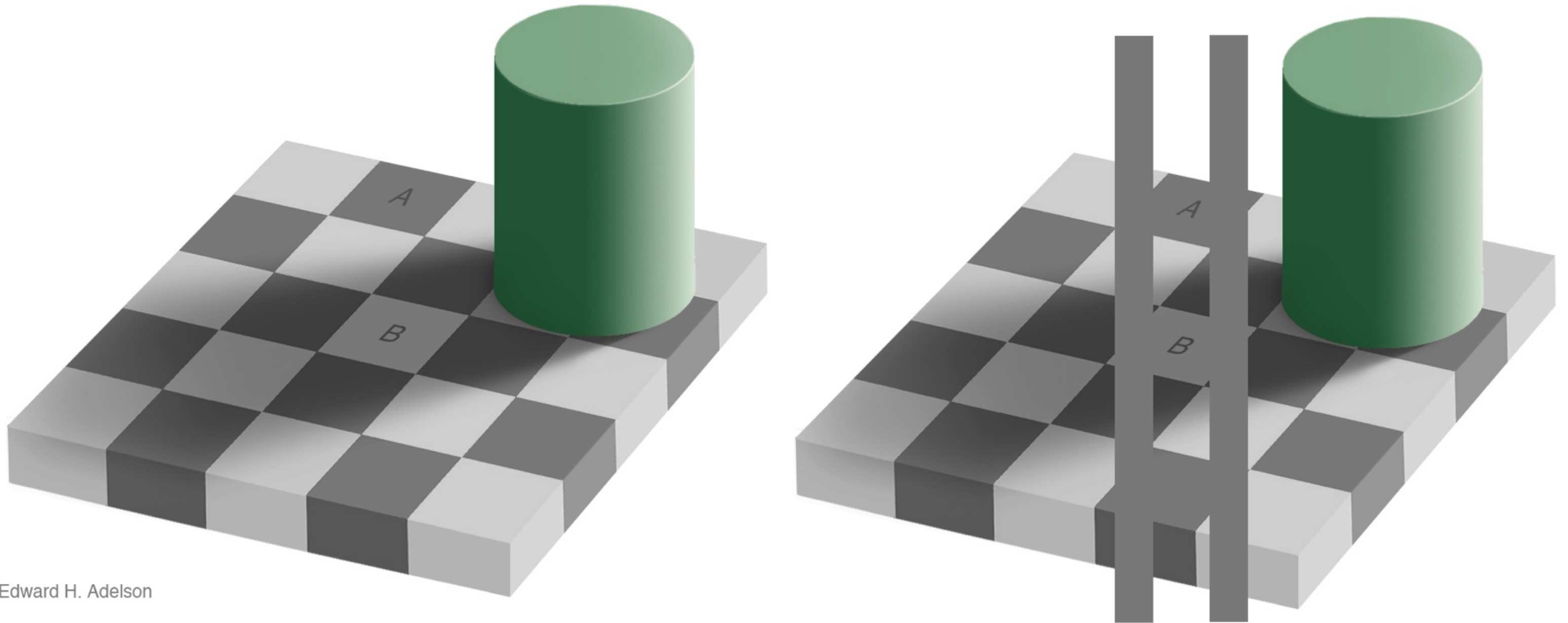
- perception of luminance is contextual based on contrast with surroundings



Edward H. Adelson

Relative luminance judgements

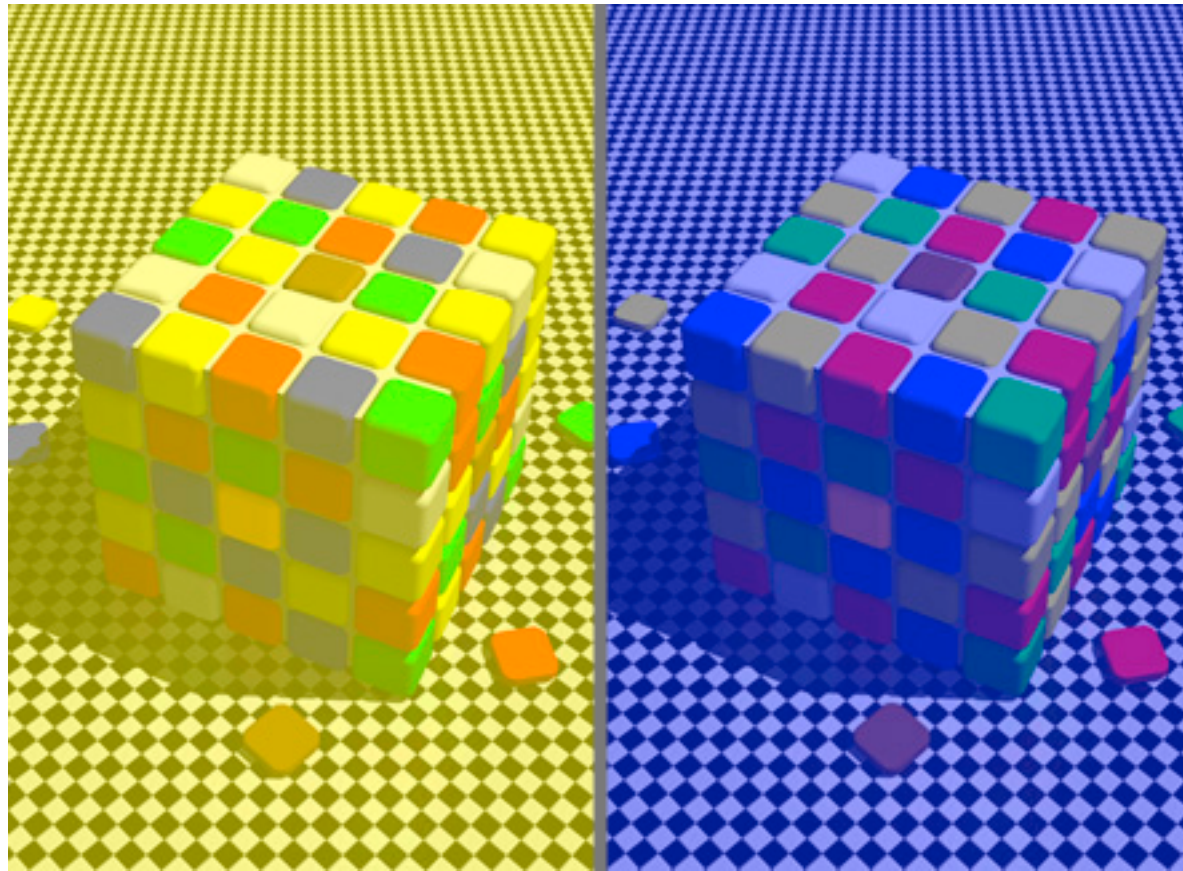
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Edward H. Adelson

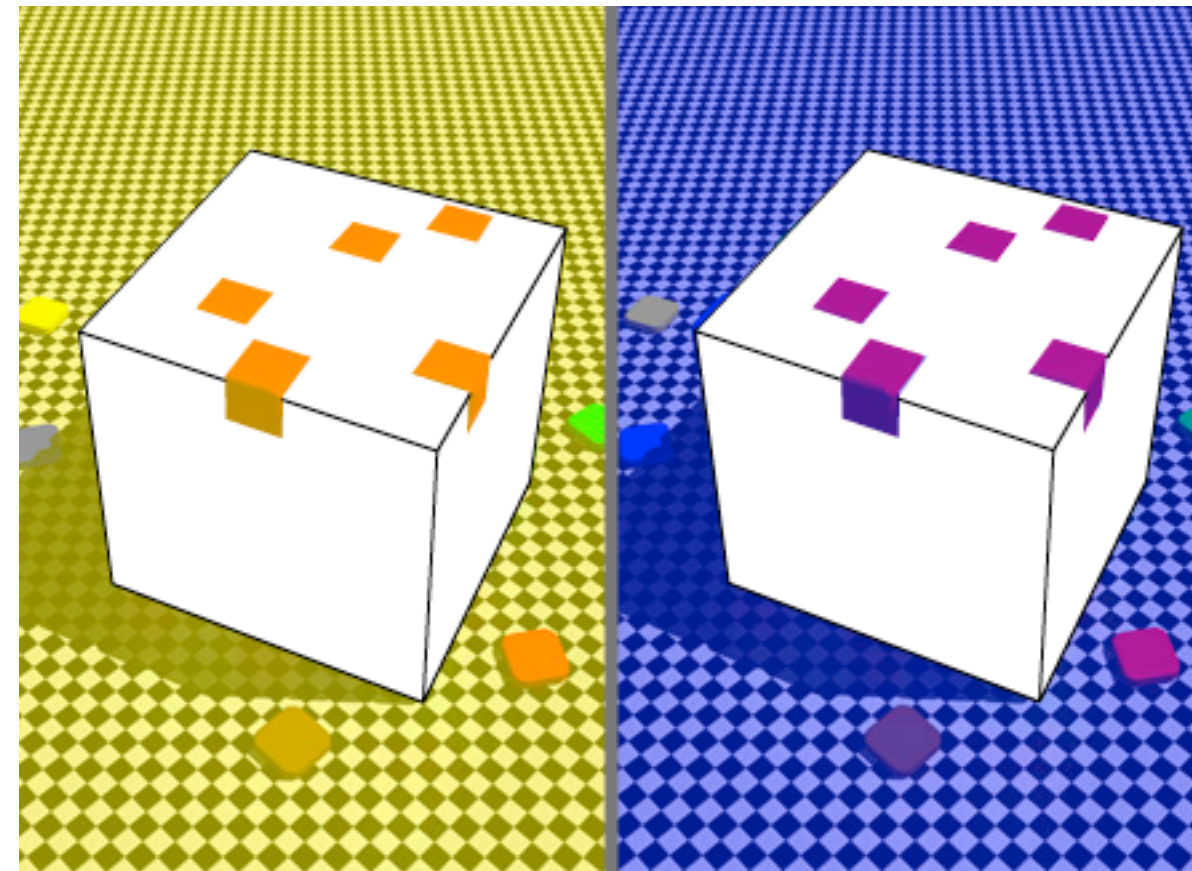
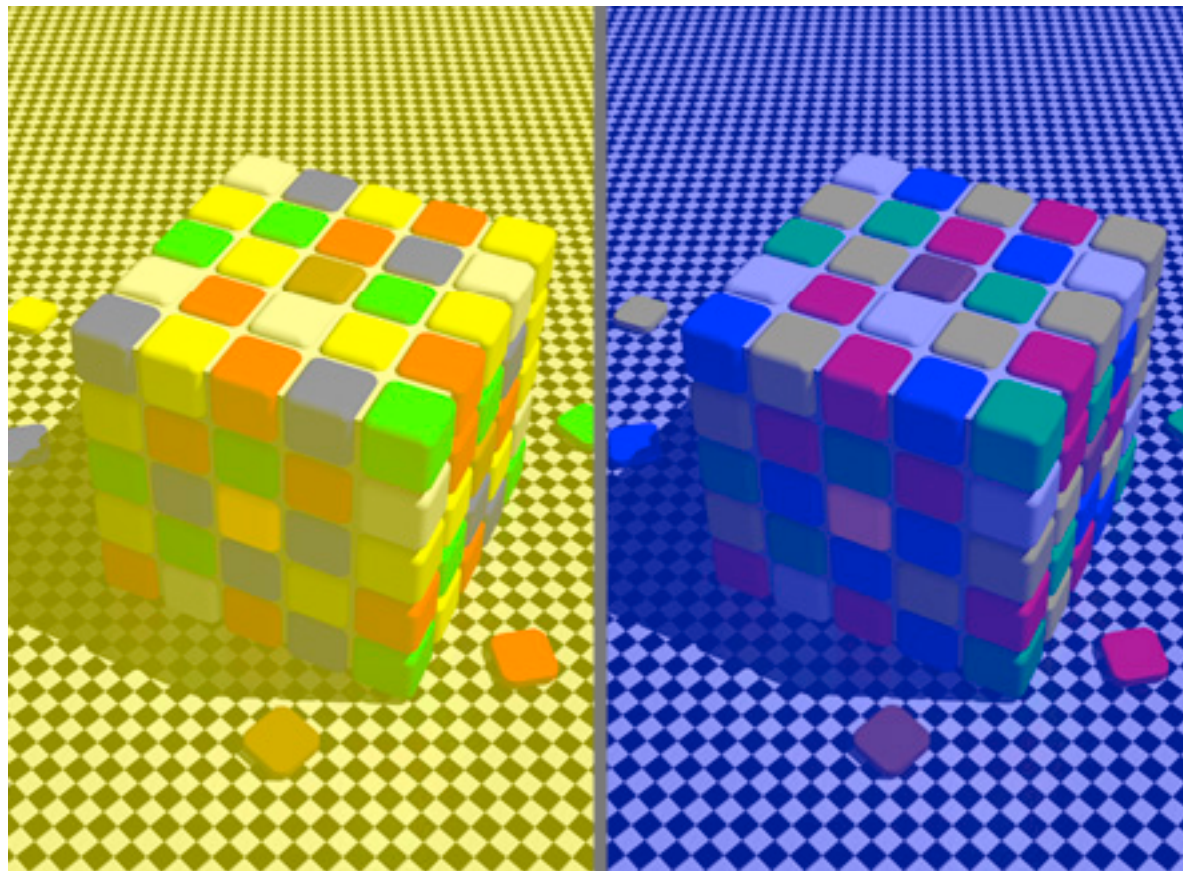
Relative color judgements

- color constancy across broad range of illumination conditions



Relative color judgements

- color constancy across broad range of illumination conditions



Grouping

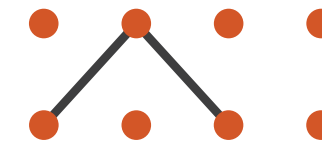
- containment
- connection
- proximity
 - same spatial region
- similarity
 - same values as other categorical channels

Marks as Links

➔ Containment



➔ Connection



➔ Identity Channels: Categorical Attributes

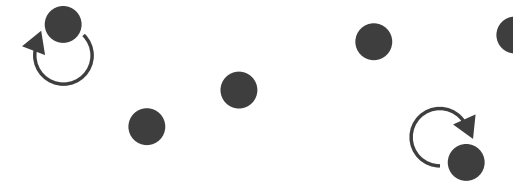
Spatial region



Color hue



Motion



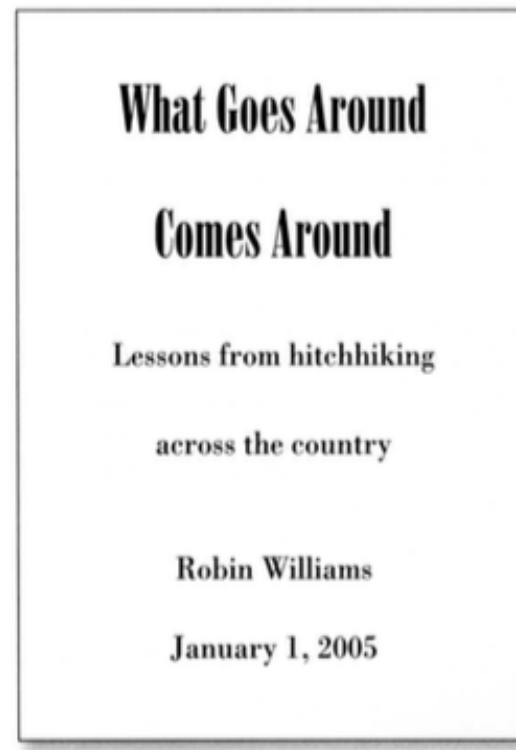
Shape



Graphic Design for Non-Designers

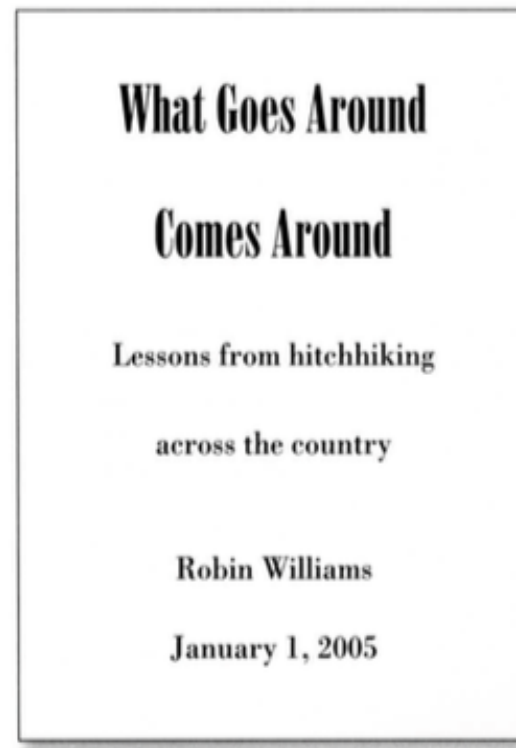
Form: Basic graphic design ideas

Form: Basic graphic design ideas



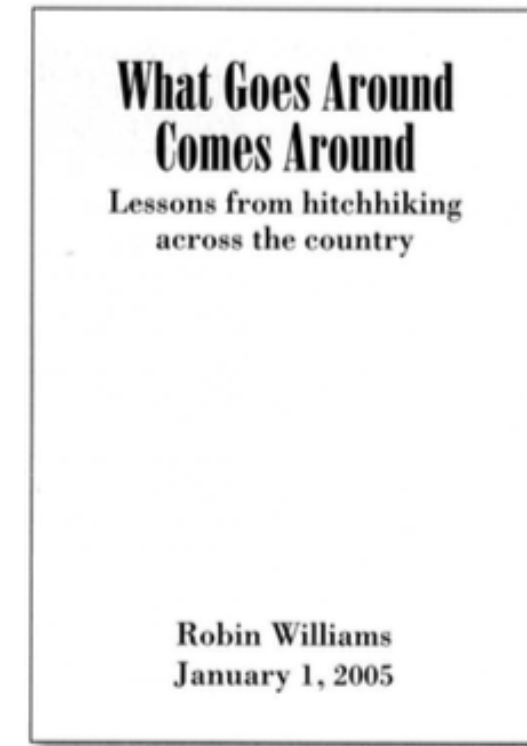
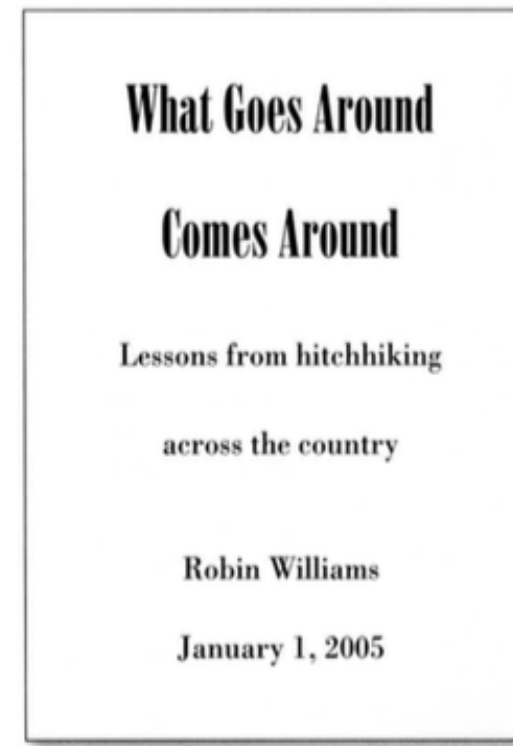
Form: Basic graphic design ideas

- proximity
 - do group related items together
 - avoid equal whitespace between unrelated



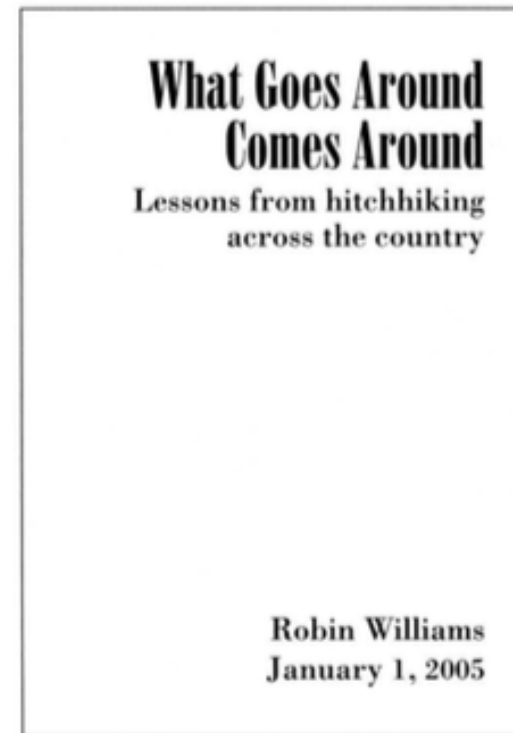
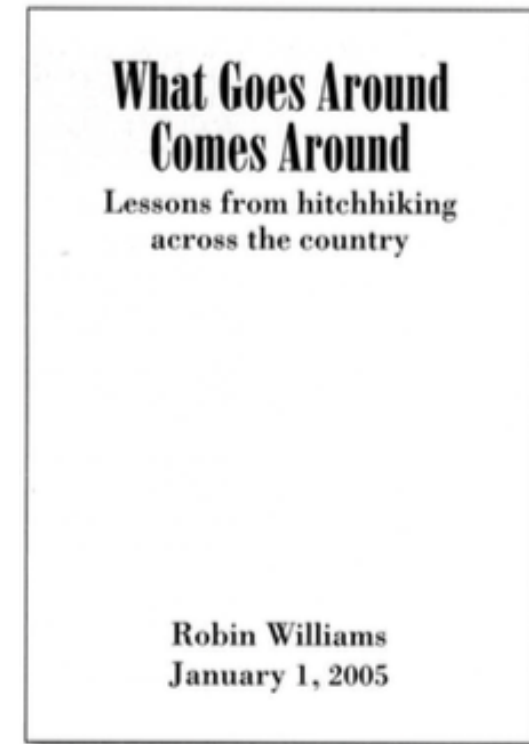
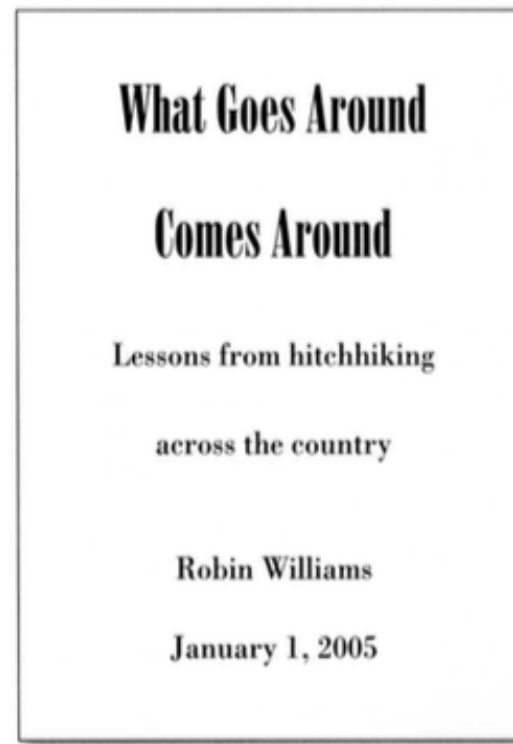
Form: Basic graphic design ideas

- proximity
 - do group related items together
 - avoid equal whitespace between unrelated
- alignment
 - do find/make strong line, stick to it
 - avoid automatic centering



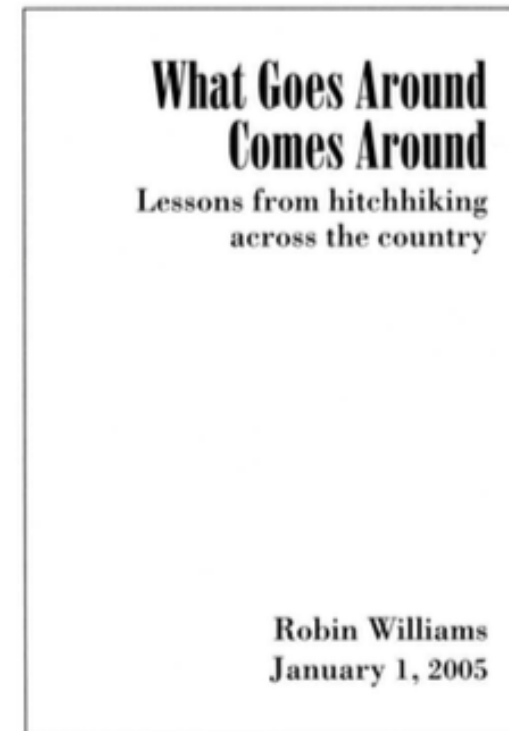
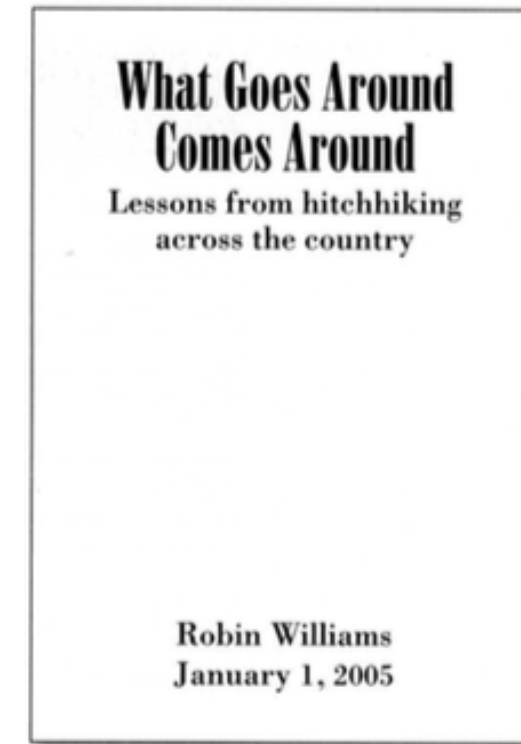
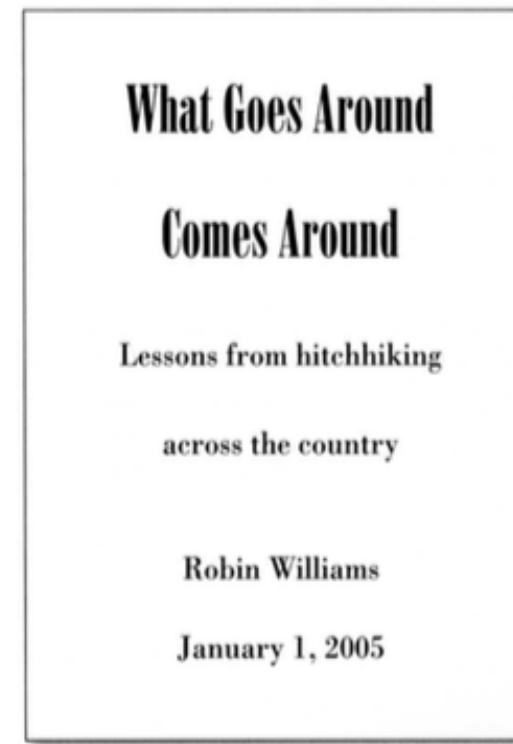
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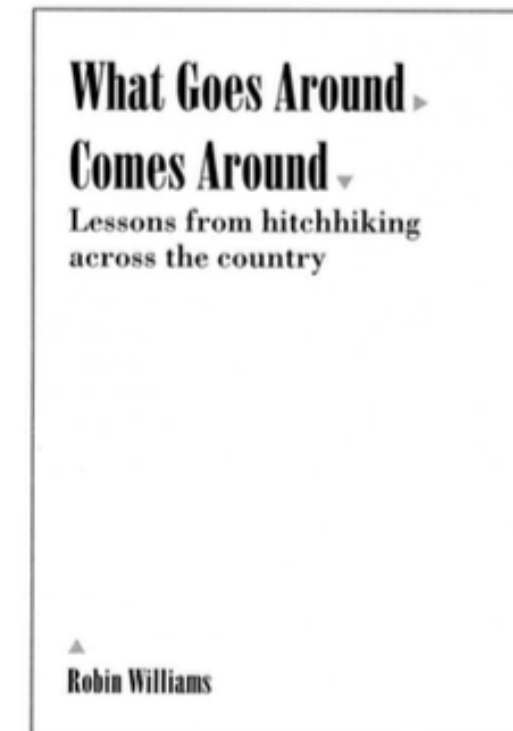
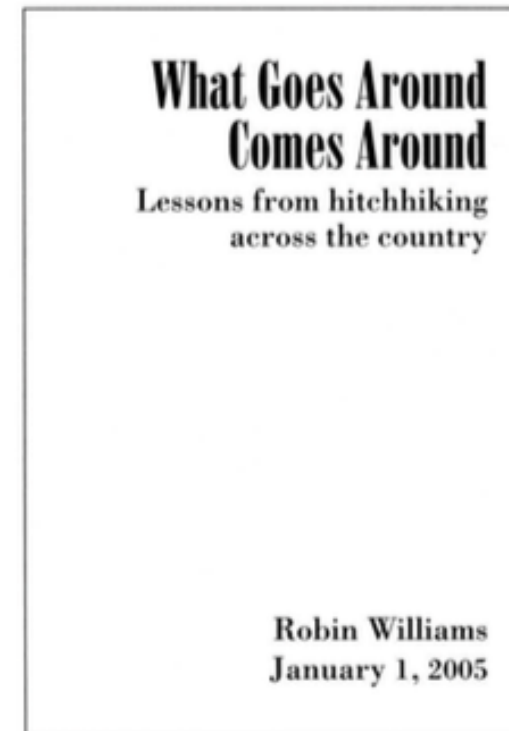
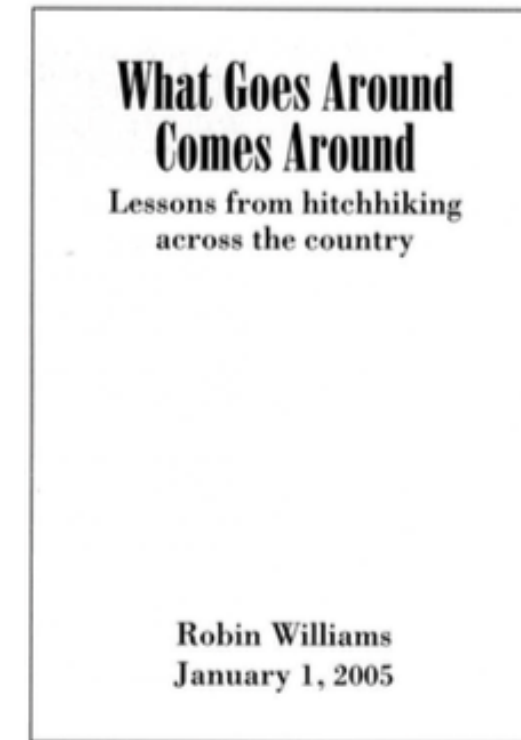
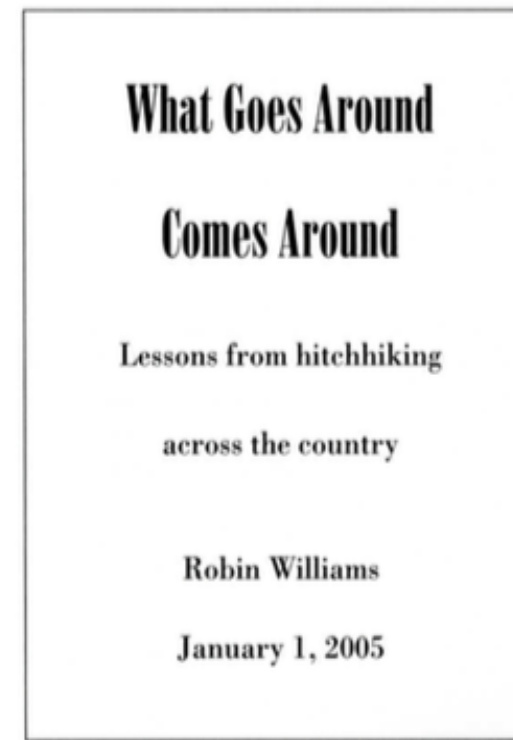
Form: Basic graphic design ideas

- proximity
 - do group related items together
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- alignment
 - do find/make strong line, stick to it
 - avoid automatic centering
- repetition
 - do unify by pushing existing consistencies



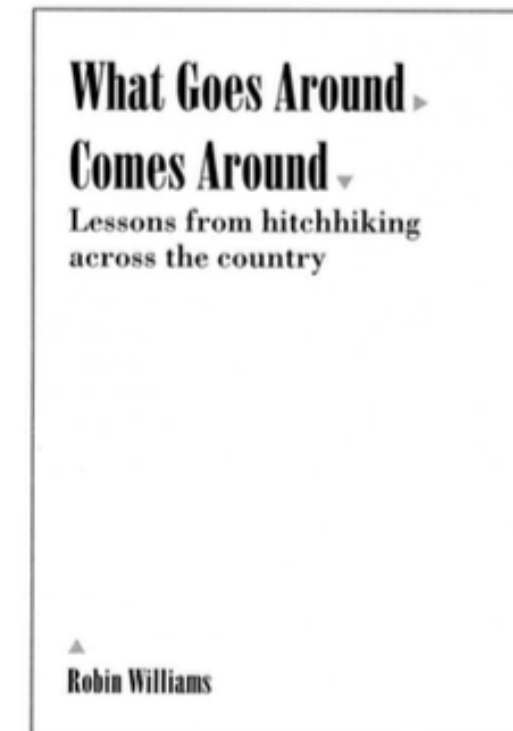
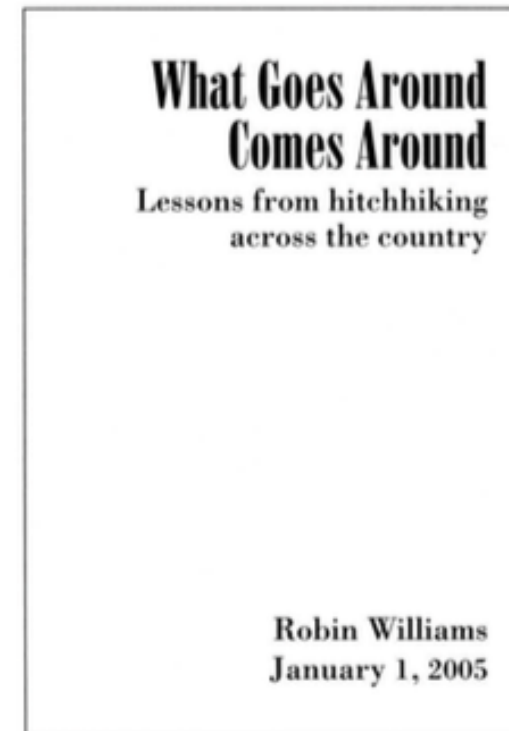
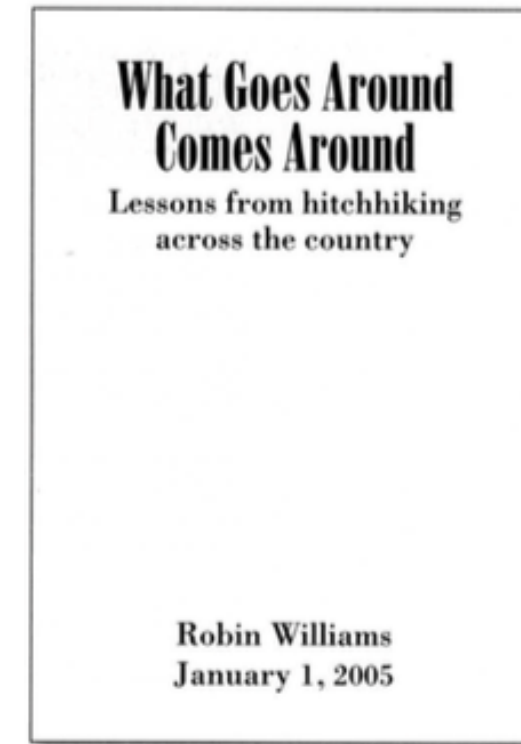
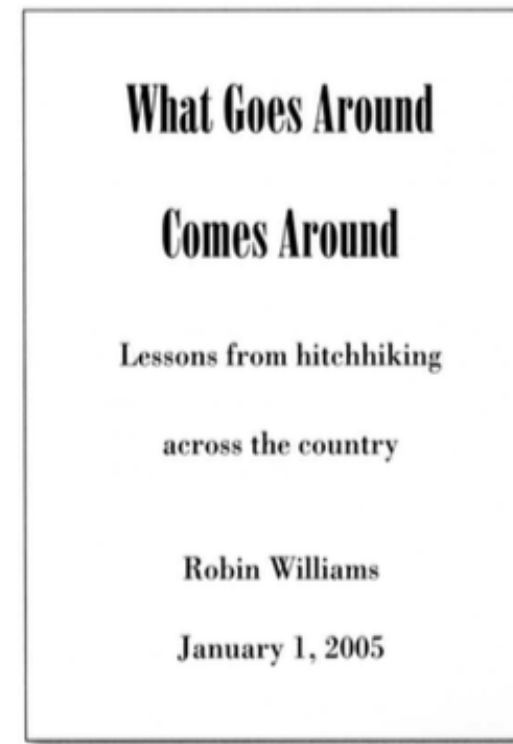
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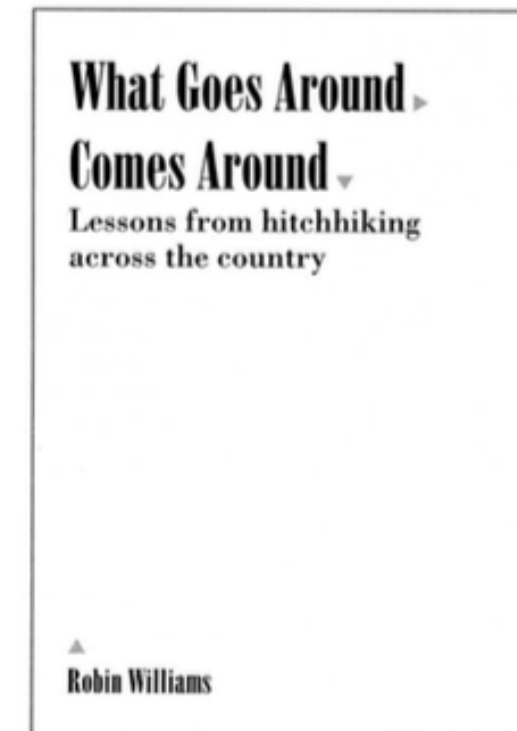
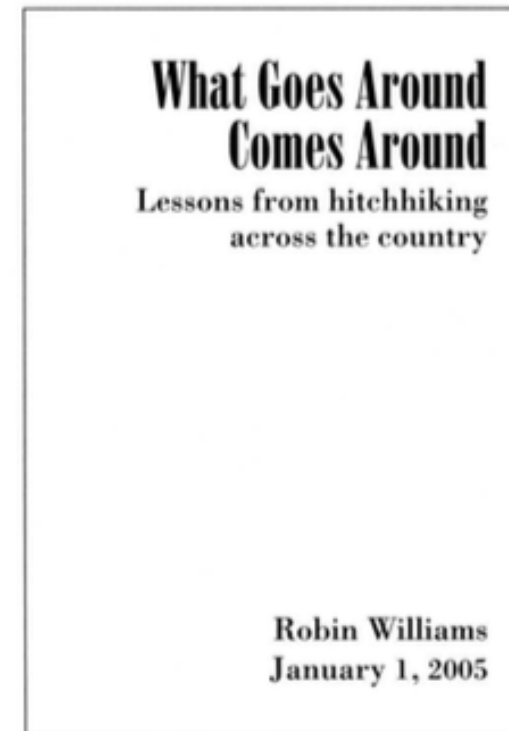
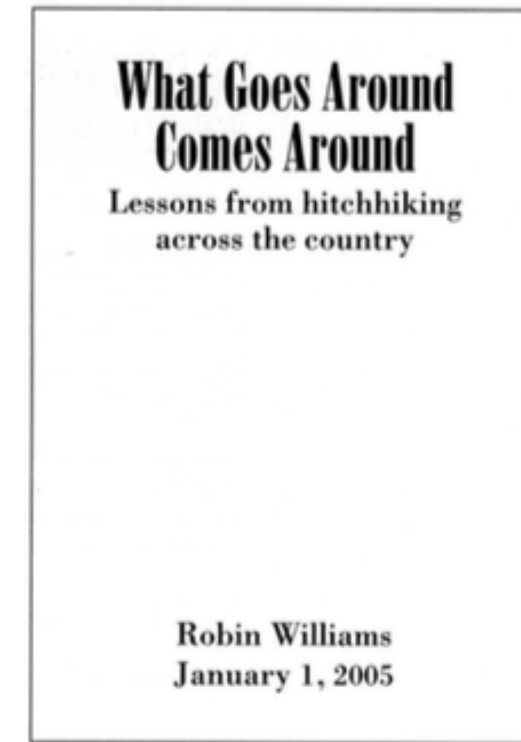
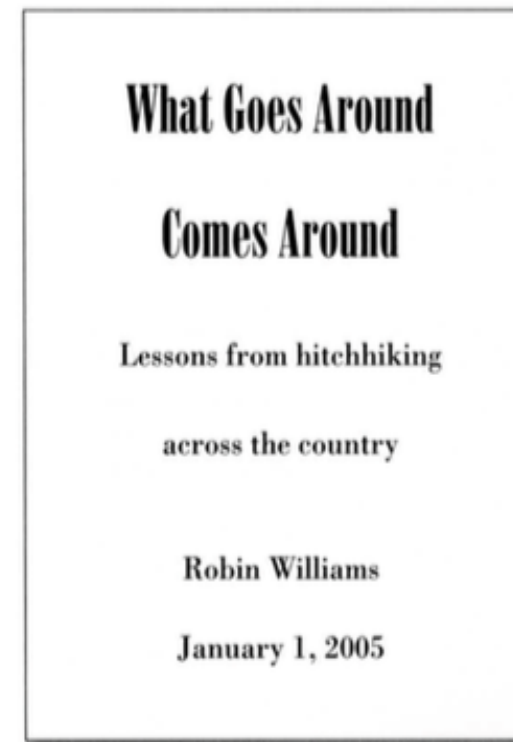
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- contrast
 - if not identical, then very different
 - avoid not quite the same



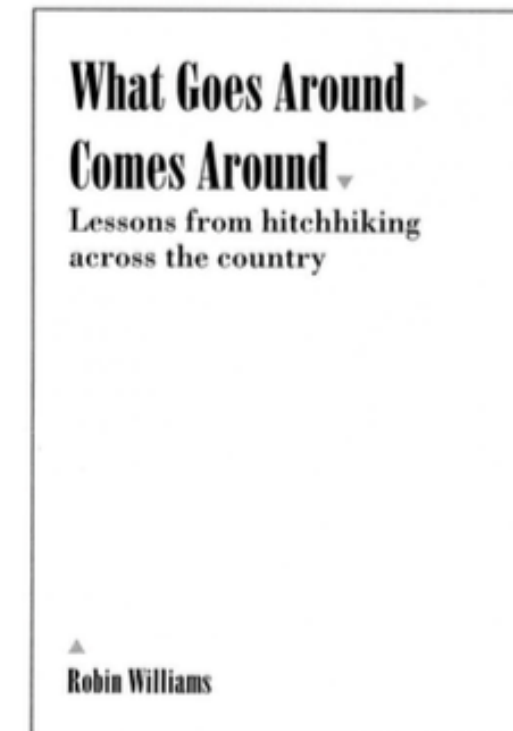
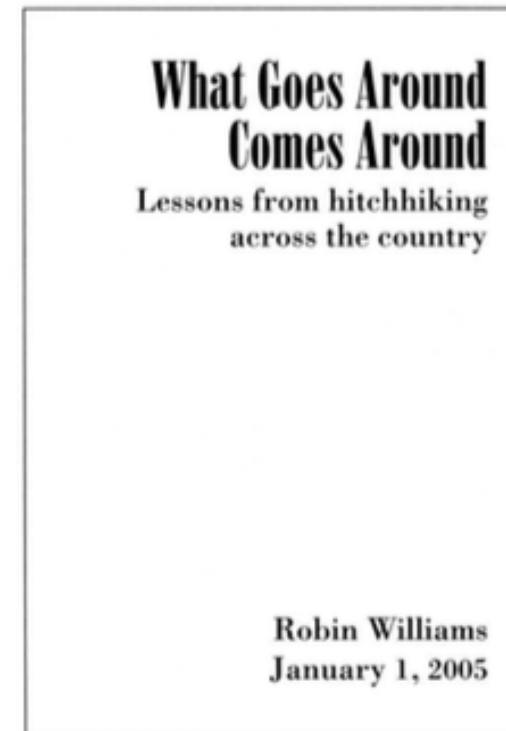
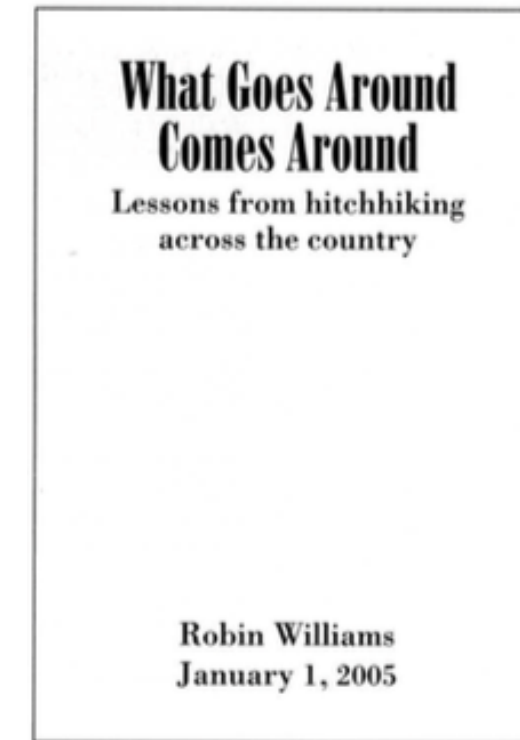
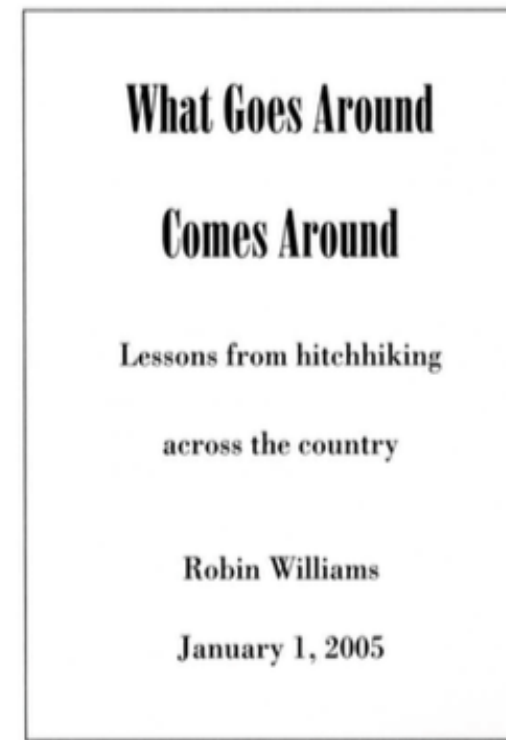
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- *The Non-Designer's Design Book, 4th ed. Robin Williams, Peachpit Press, 2015.*
 - fast read, very practical to work through whole thing

Function first, form next

- dangerous to start with aesthetics
 - usually impossible to add function retroactively
- start with focus on functionality
 - possible to improve aesthetics later on, as refinement
 - if no expertise in-house, find good graphic designer to work with
 - aesthetics do matter! another level of function
 - visual hierarchy, alignment, flow
 - Gestalt principles in action

Usability Testing

Guerilla/Discount Usability

- usability testing as formative evaluation: how could it improve?
 - vs summative evaluation: did it work?
- grab a few people and watch them use your interface
 - even 3-5 gives substantial coverage of major usability problems
 - agile/lean qualitative, vs formal quantitative user studies
 - goal is not statistical significance!
- think-aloud protocol
 - contextual inquiry (conversations back and forth) vs fly on the wall (you're silent)

Further reading, usability

- 7 Step Guide to Guerrilla Usability Testing, Markus Piper
 - <https://userbrain.net/blog/7-step-guide-guerrilla-usability-testing-diy-usability-testing-method>
- Discount Usability: 20 Years, Jakob Nielsen
 - <https://www.nngroup.com/articles/discount-usability-20-years/>
- Interaction Design: Beyond Human-Computer Interaction
 - Preece, Sharp, Rogers. Wiley, 5th edition, 2019.
- About Face: The Essentials of Interaction Design
 - Cooper, Reimann, Cronin, Noessel. Wiley, 4th edition, 2014.
- Task-Centered User Interface Design. Lewis & Rieman, 1994
 - <http://hcibib.org/tcuid/>
- Designing with the Mind in Mind. Jeff Johnson. Morgan Kaufmann, 2nd, 2014.

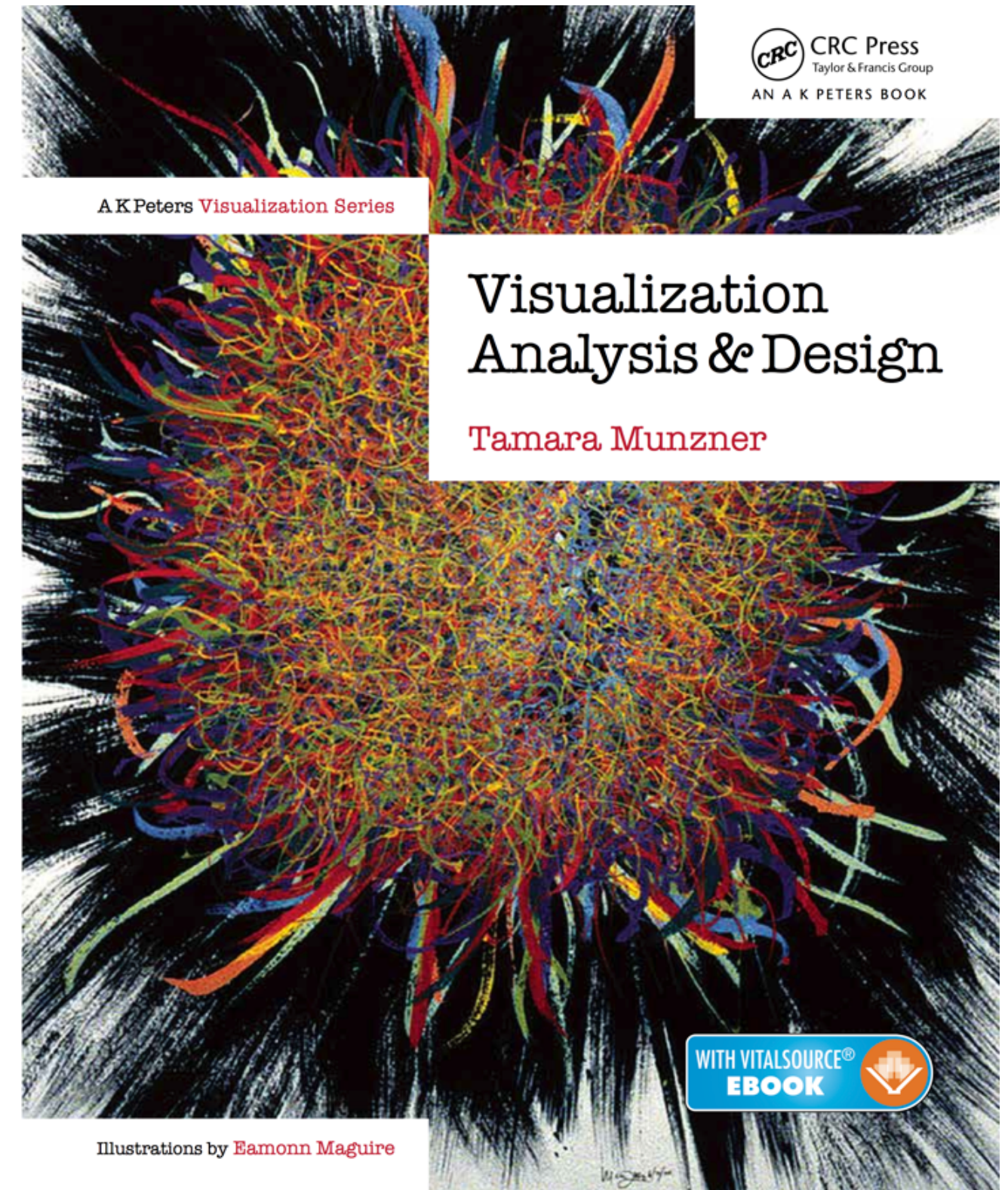
More Resources: Books

Visualization Analysis and Design

- book from which these tidbits were drawn
 - illustration acknowledgement: Eamonn Maguire
- full courses, papers, videos, software, talks
 - <http://www.cs.ubc.ca/group/infovis>
 - <http://www.cs.ubc.ca/~tmm>

<https://www.cs.ubc.ca/~tmm/vadbook>

<https://www.routledge.com/Visualization-Analysis-and-Design/Munzner/p/book/9781466508910>

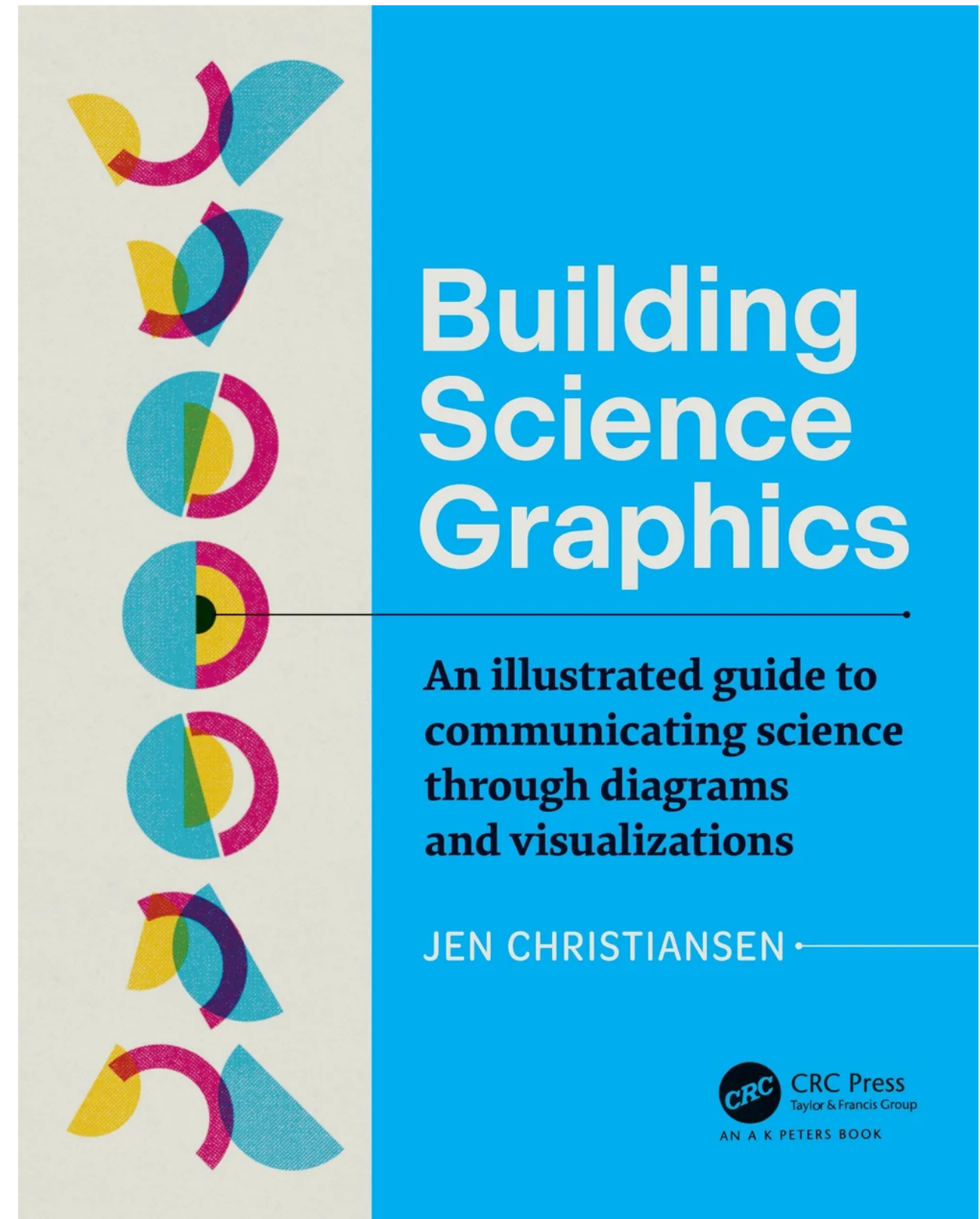


Building Science Graphics

- Building Science Graphics:
An illustrated guide to
communicating science through
diagrams and visualizations
–Jen Christiansen

<https://www.buildingsciencegraphics.com/>

<https://www.routledge.com/Building-Science-Graphics-An-Illustrated-Guide-to-Communicating-Science-through-Diagrams-and-Visualizations/Christiansen/p/book/9781032106748>



CHART

- CHART: Designing Creative Data Visualizations from Charts to Art
– Nadieh Bremer

<https://www.visualcinnamon.com/chart/>

<https://www.routledge.com/CHART-Designing-Creative-Data-Visualizations-from-Charts-to-Art/Bremer/p/book/9781032797755>

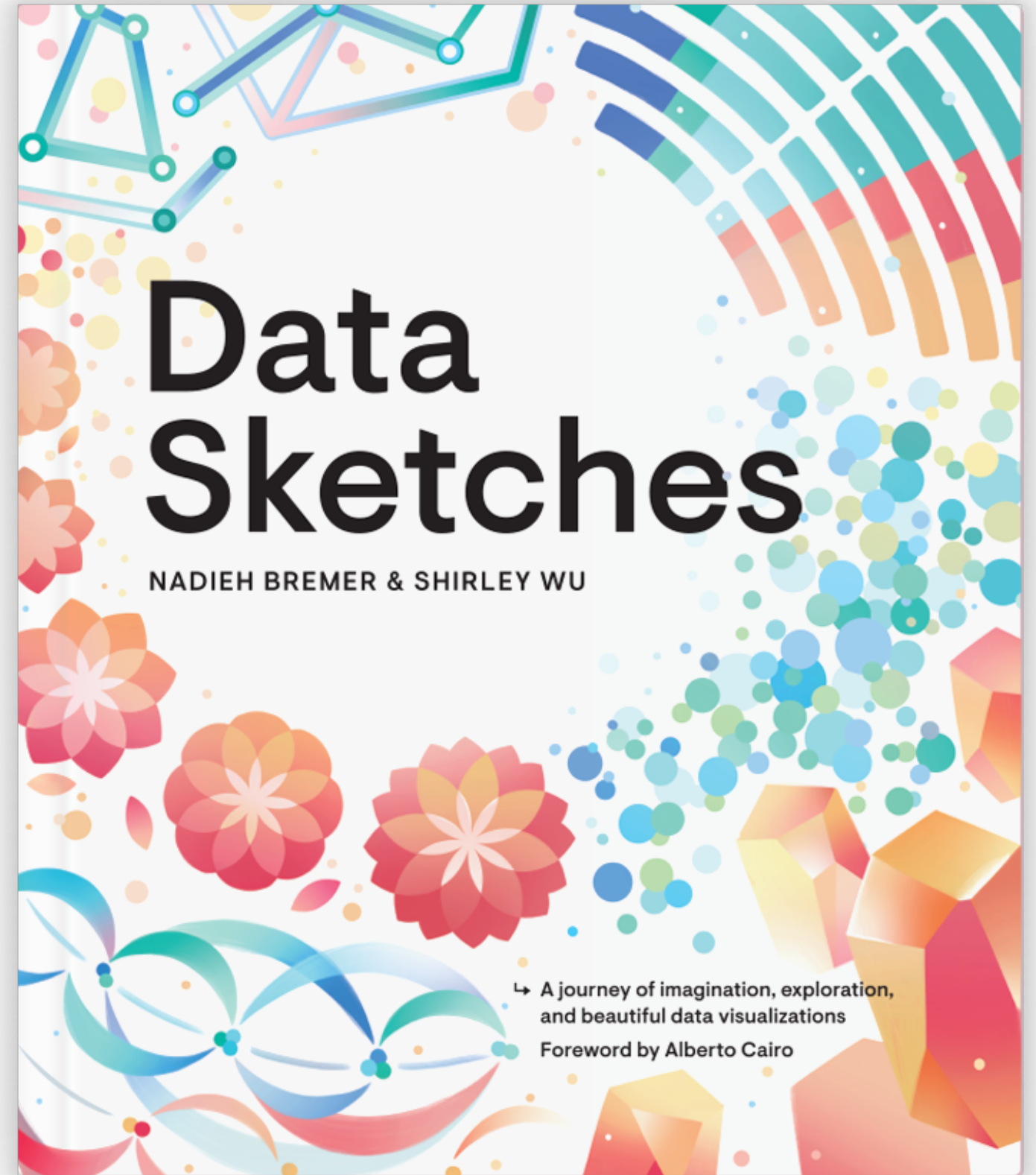


Data Sketches

- Data Sketches:
A journey of imagination,
exploration, and beautiful data
visualizations
– Nadieh Bremer & Shirley Wu

<https://www.datasketch.es/book>

<https://www.routledge.com/Data-Sketches-A-journey-of-imagination-exploration-and-beautiful-data-visualizations/Bremer-Wu/p/book/9780367000080>

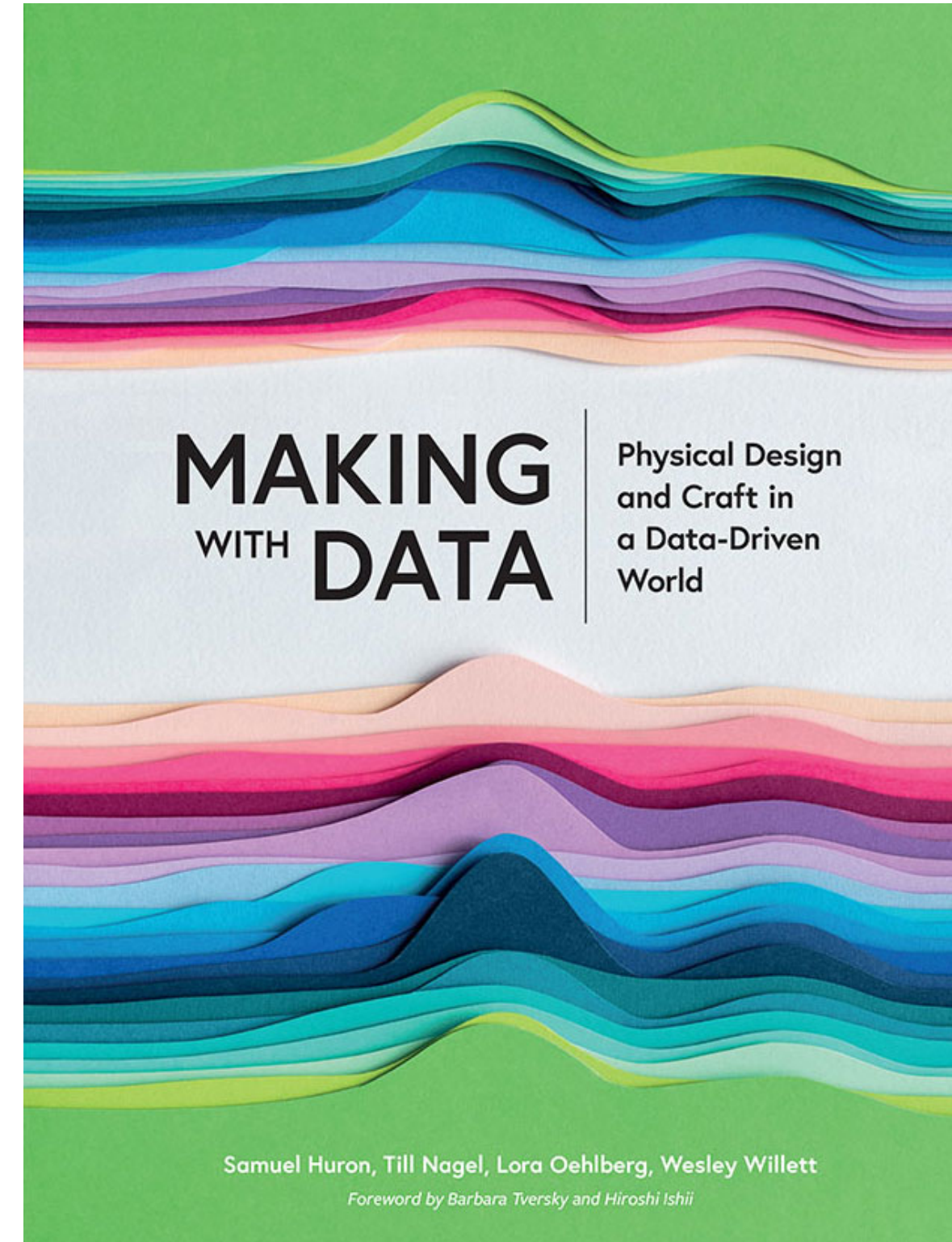


Making with Data

- Making with Data: Physical Design and Craft in a Data-Driven World
 - editors:
Samuel Huron, Till Nagel,
Lora Oehlberg, Wesley Willett

<https://makingwithdata.org/>

<https://www.routledge.com/Making-with-Data-Physical-Design-and-Craft-in-a-Data-Driven-World/Huron-Nagel-Oehlberg-Willett/p/book/9781032182223>

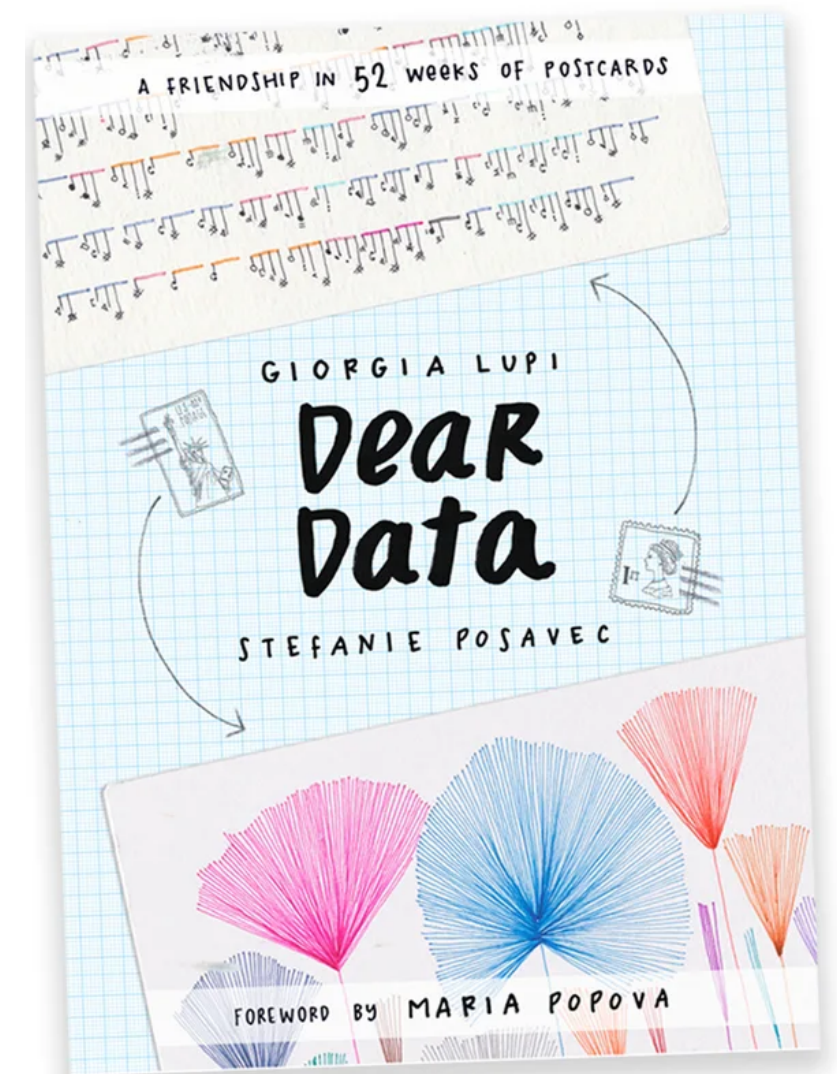


Dear Data: A Friendship in 52 Weeks of Postcards

- inspiring celebration of data humanism



Giorgia Lupi and
Stefanie Posavec



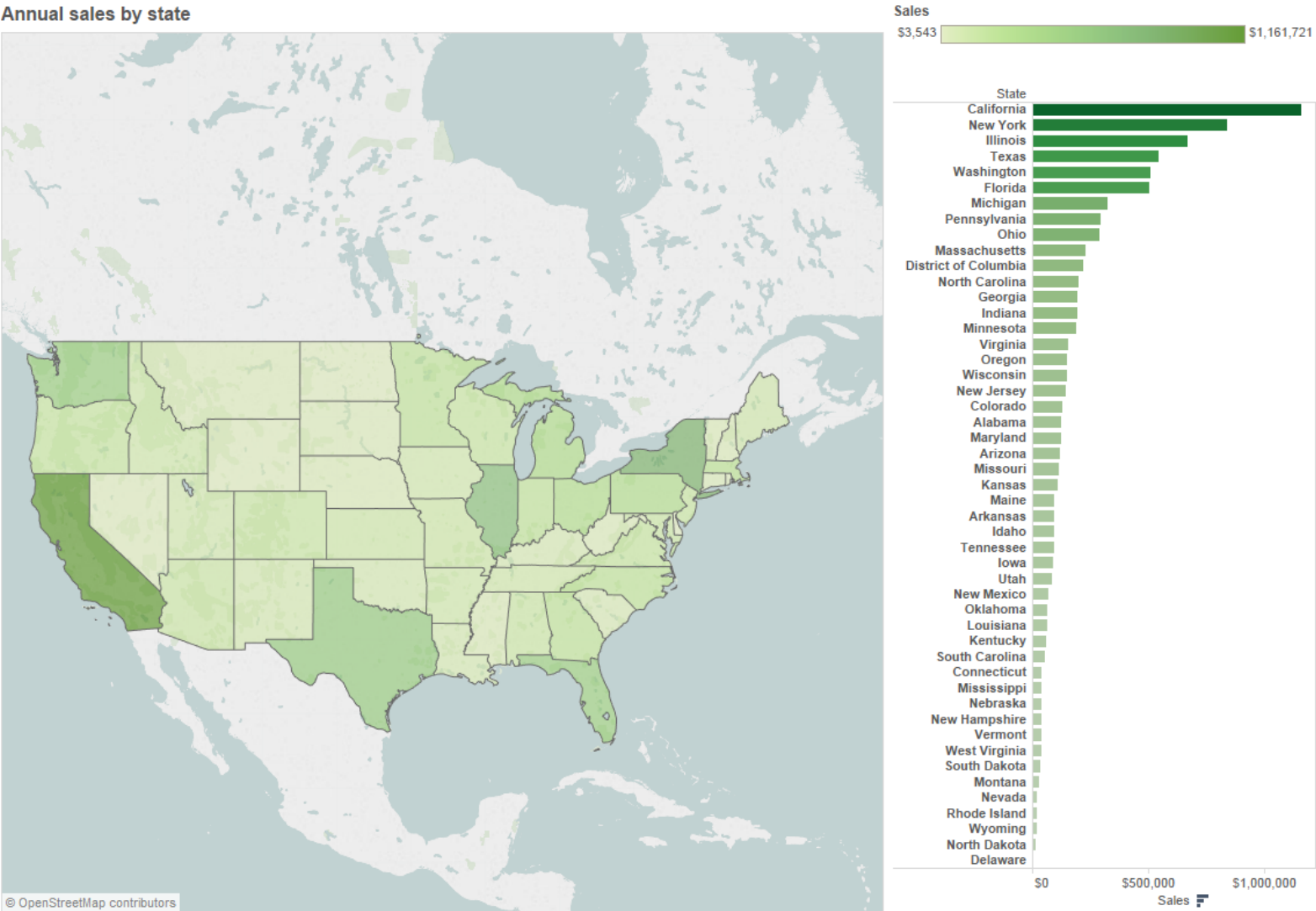
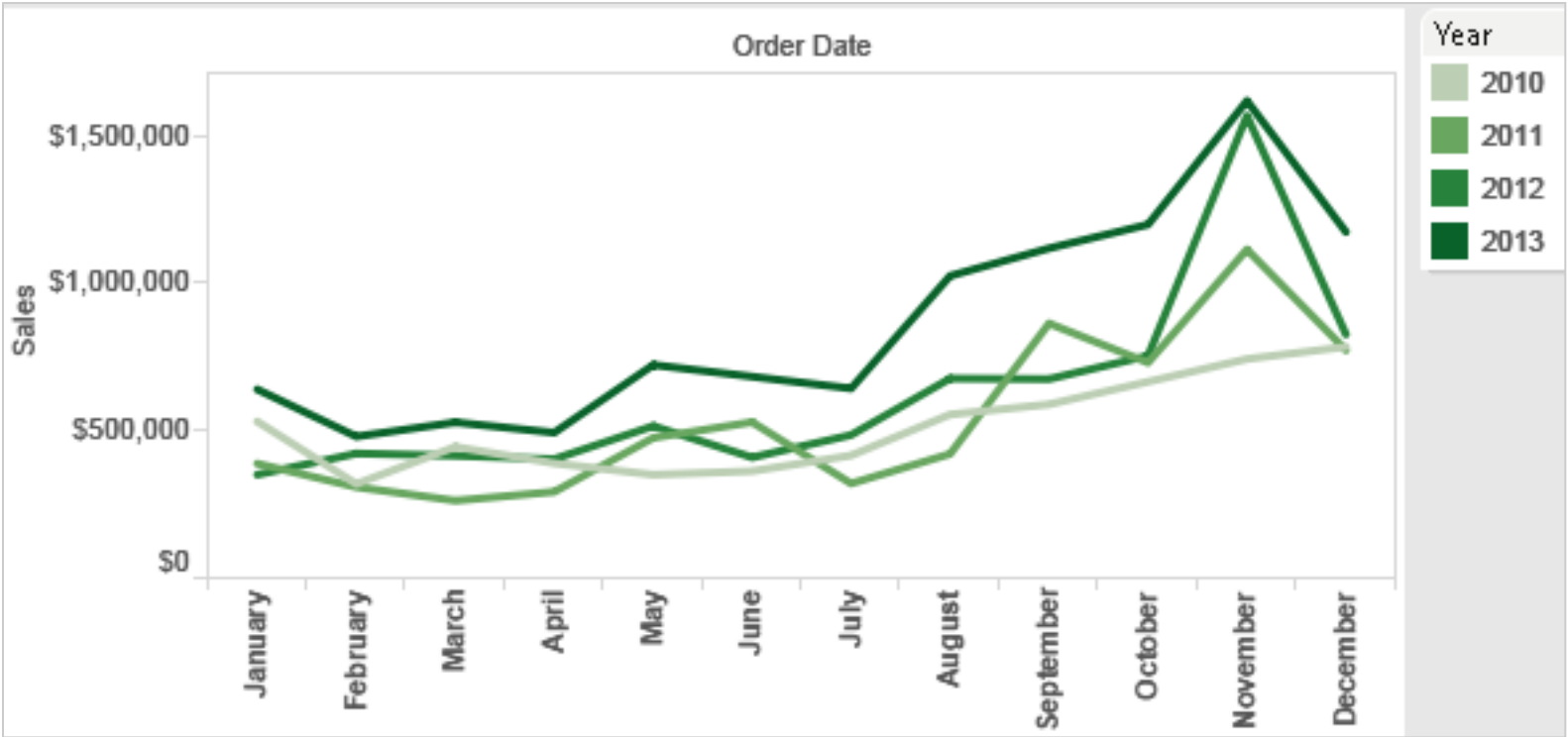
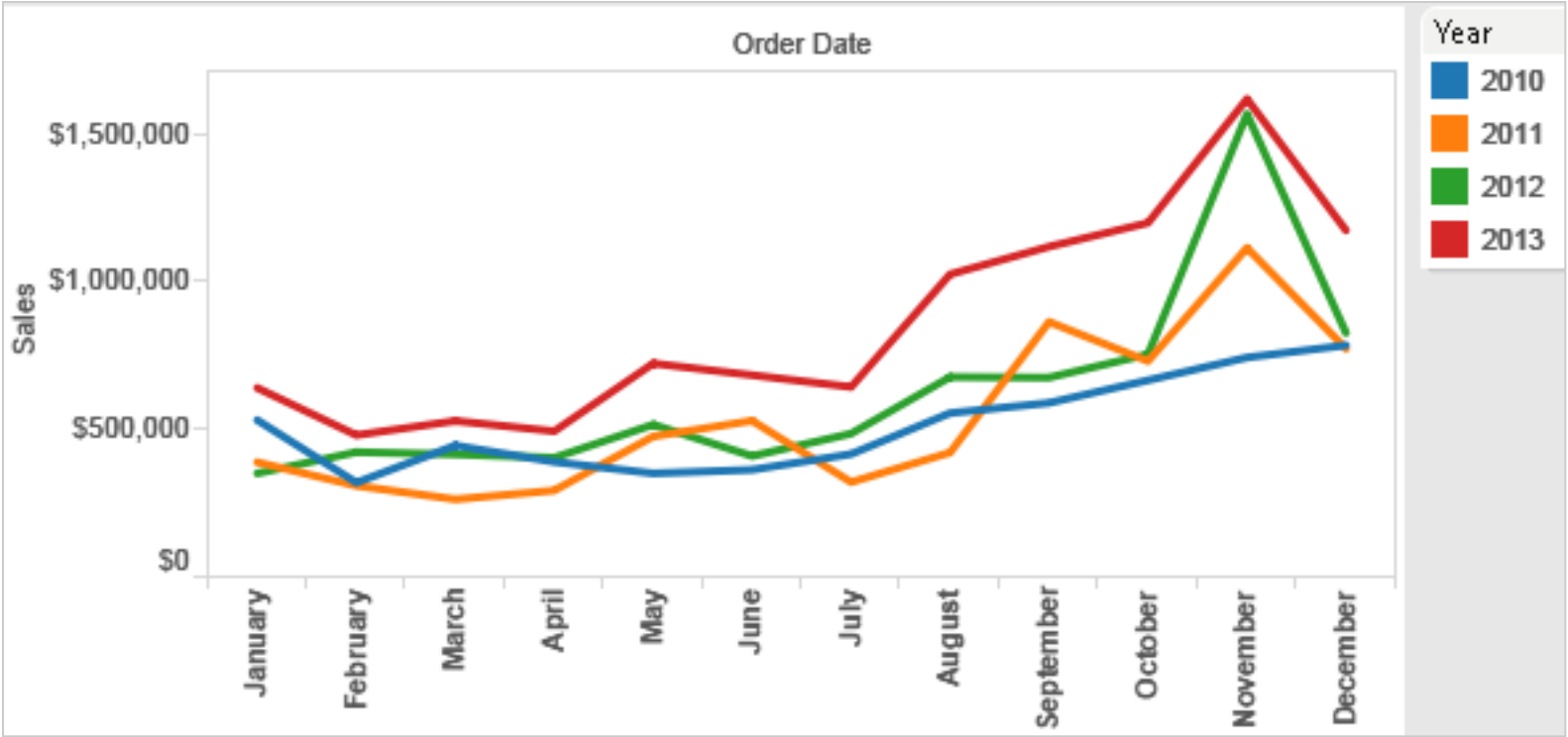
<http://www.dear-data.com/by-week/>

<https://giorgialupi.com/dear-data>

<https://www.stefanieposavec.com/dear-data>

Color

Categorical vs ordered color



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

Decomposing color

- first rule of color: do not talk about color!
 - color is confusing if treated as monolithic

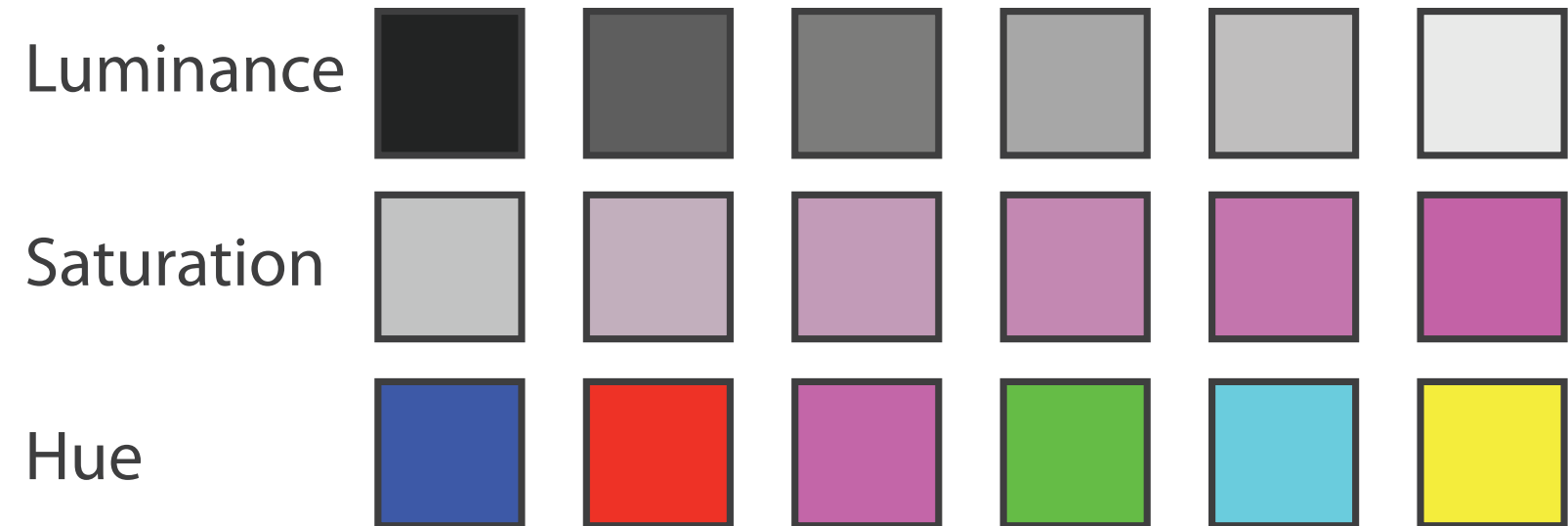
- decompose into three channels

- ordered can show magnitude

- luminance: how bright
 - saturation: how colorful

- categorical can show identity

- hue: what color



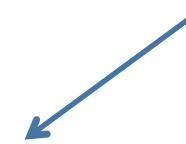
- channels have different properties

- what they convey directly to perceptual system

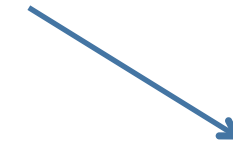
- how much they can convey: how many discriminable bins can we use?

Luminance

- need luminance for edge detection
 - fine-grained detail only visible through luminance contrast
 - legible text requires luminance contrast!
- intrinsic perceptual ordering



Luminance information



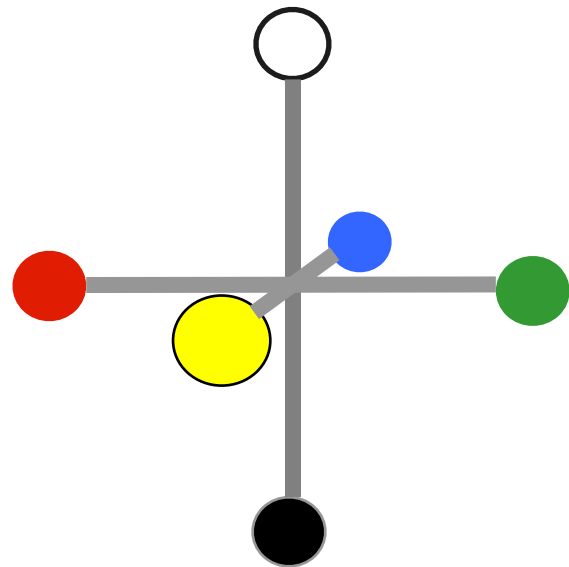
Chroma information



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

Opponent color and color deficiency

- perceptual processing before optic nerve
 - one achromatic luminance channel (L^*)
 - edge detection through luminance contrast
 - 2 chroma channels
 - red-green (a^*) & yellow-blue axis (b^*)
- “color blind”: one axis has degraded acuity
 - 8% of men are red/green color deficient
 - blue/yellow is rare



Luminance information



Chroma information



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

Color spaces

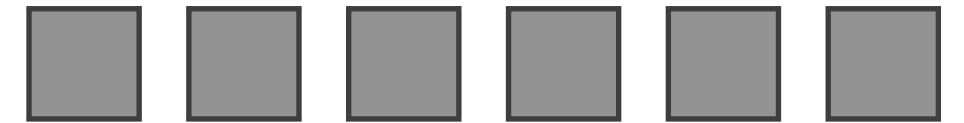
- CIE $L^*a^*b^*$: good for computation
 - L^* intuitive: perceptually linear luminance
 - a^*b^* axes: perceptually linear but nonintuitive
- RGB: good for display hardware
 - poor for encoding
- HSL/HSV: somewhat better for encoding
 - hue/saturation wheel intuitive
 - beware: only pseudo-perceptual!
 - lightness (L) or value (V) $\neq$ luminance or L^*
- Luminance, hue, saturation
 - good for encoding
 - but not standard graphics/tools colorspace

Corners of the RGB color cube

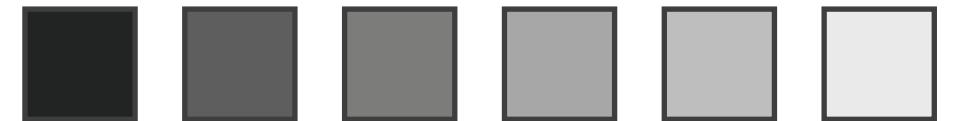


L from HLS

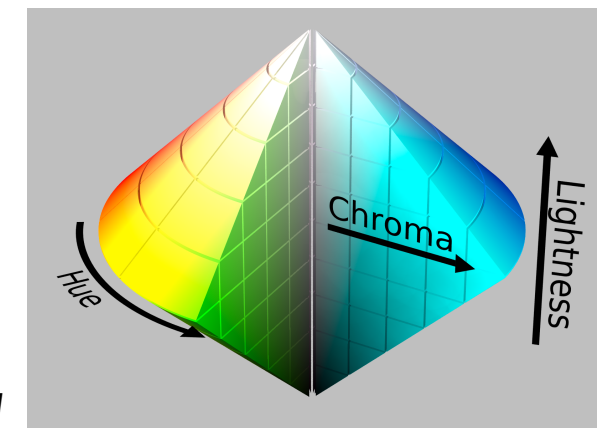
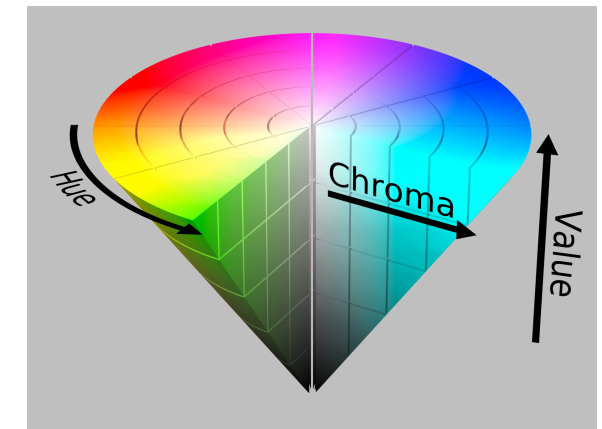
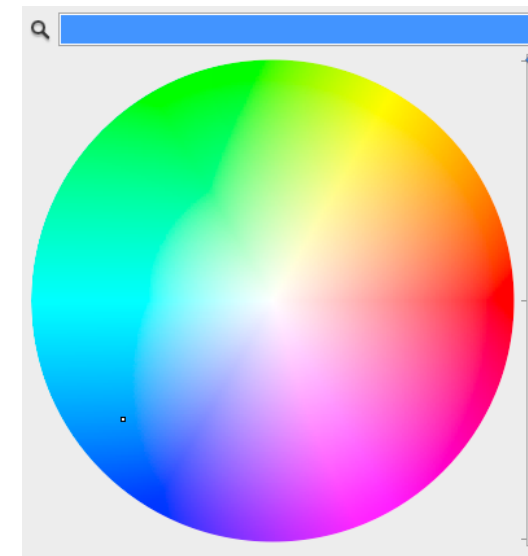
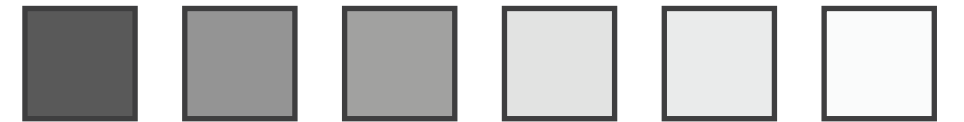
All the same



Luminance values



L^* values



[https://en.wikipedia.org/wiki/HSL_and_HSV]

Designing for color deficiency: Check with simulator



**Normal
vision**



Deuteranope

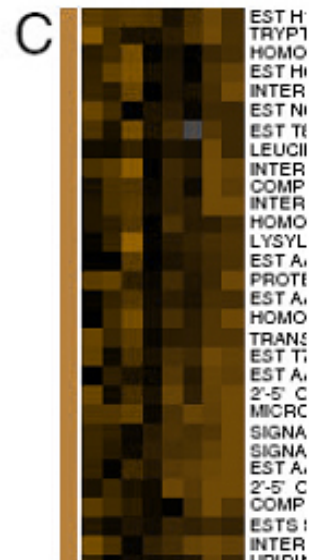
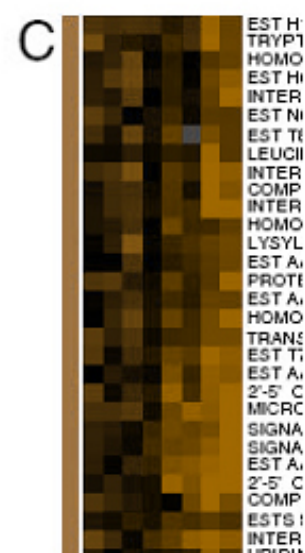
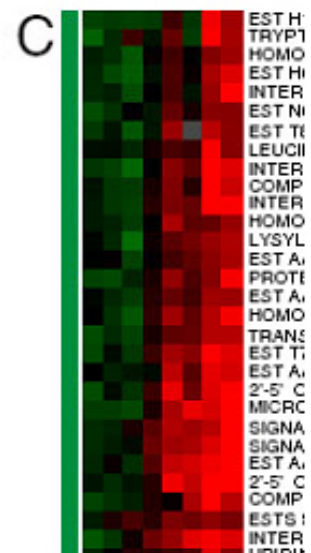


Protanope



Tritanope

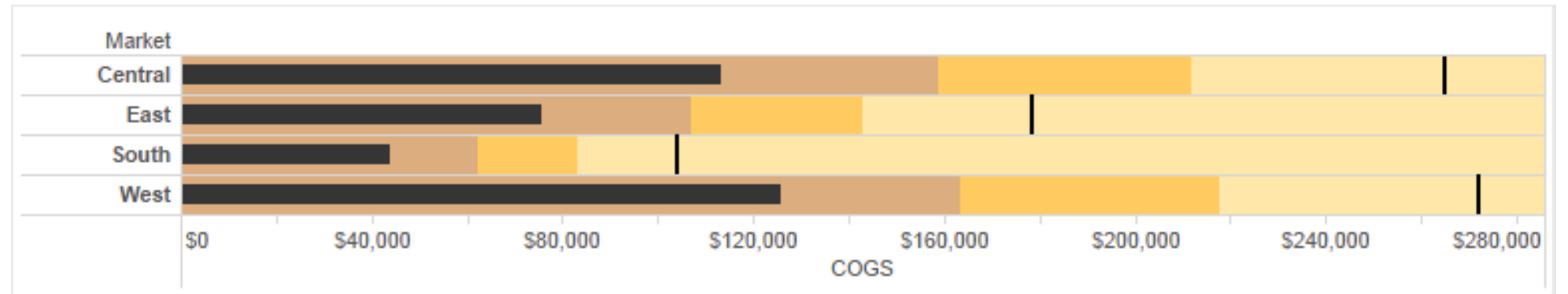
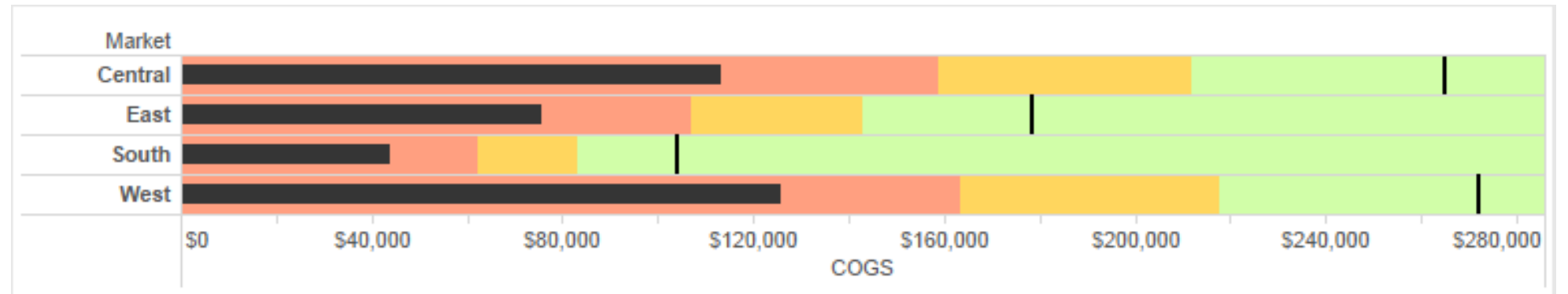
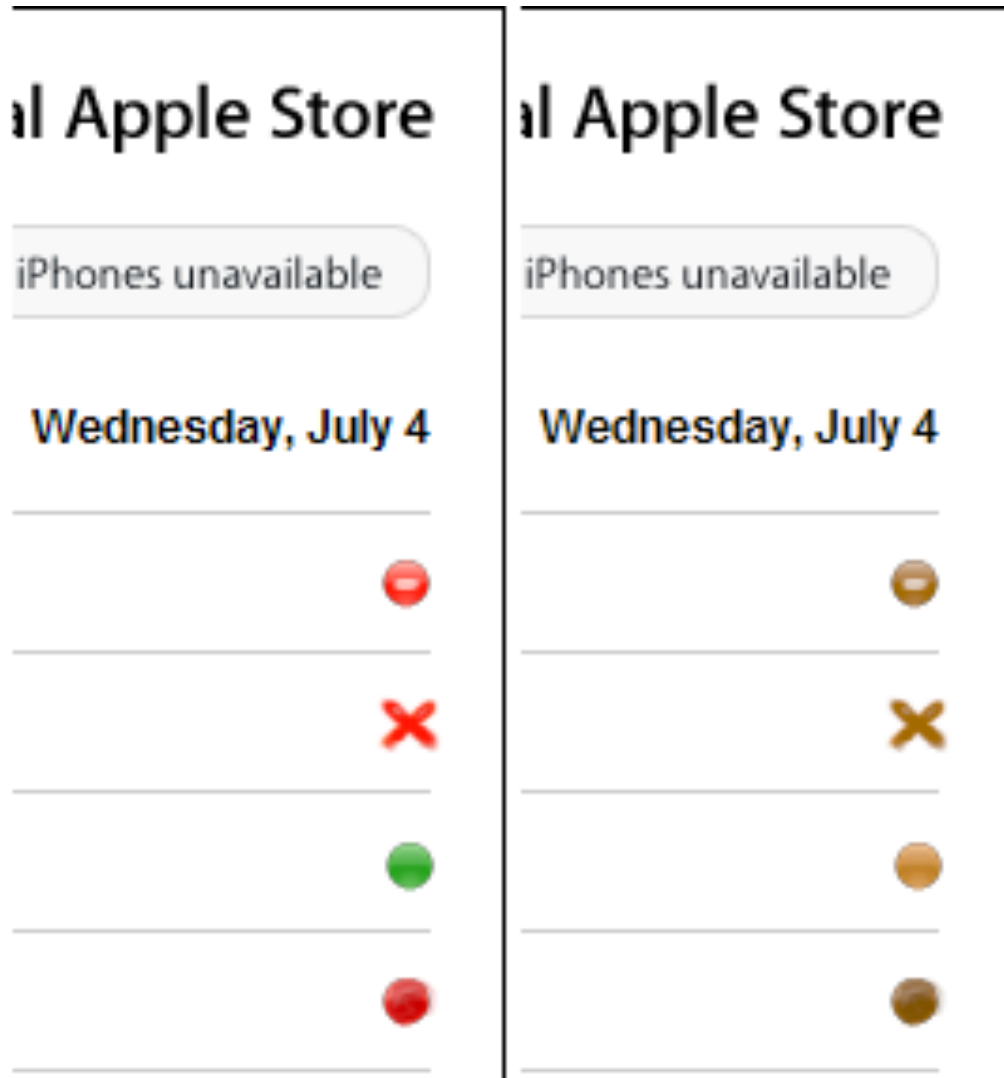
<http://rehue.net>



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

Designing for color deficiency: Avoid encoding by hue alone

- redundantly encode
 - vary luminance
 - change shape

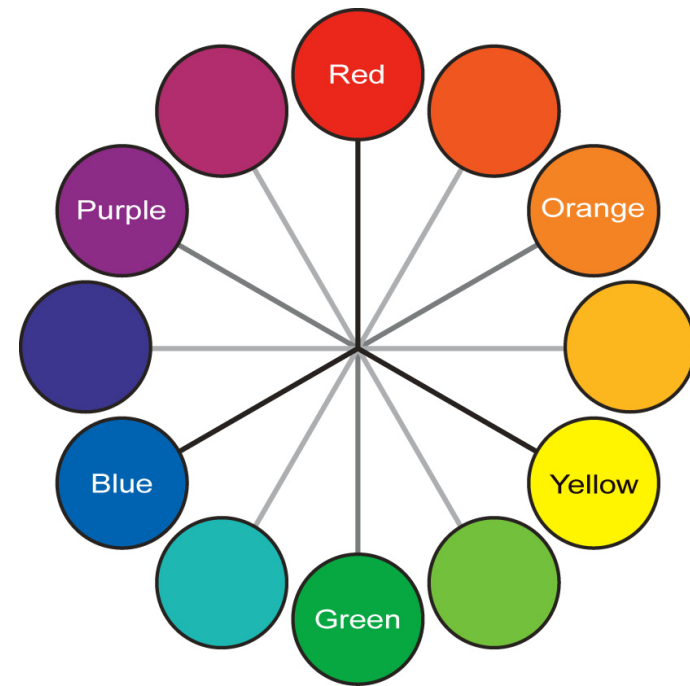


Deuteranope simulation

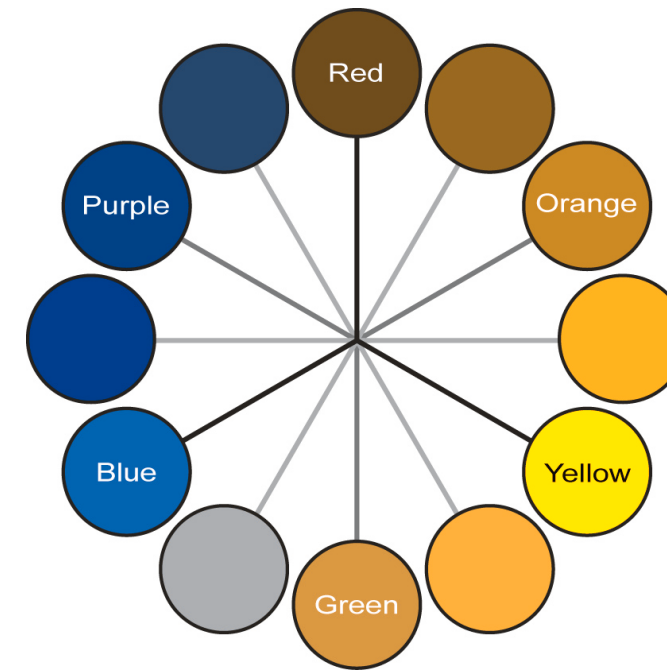
Change the shape

Vary luminance

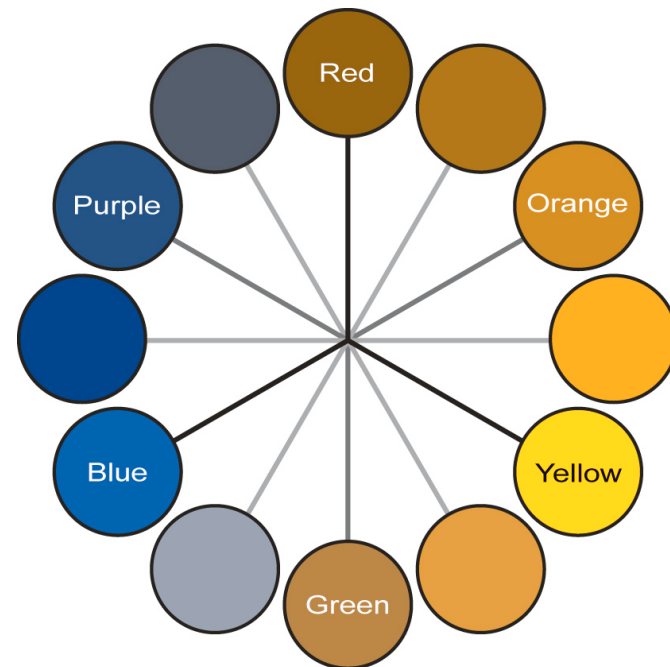
Color deficiency: Reduces color to 2 dimensions



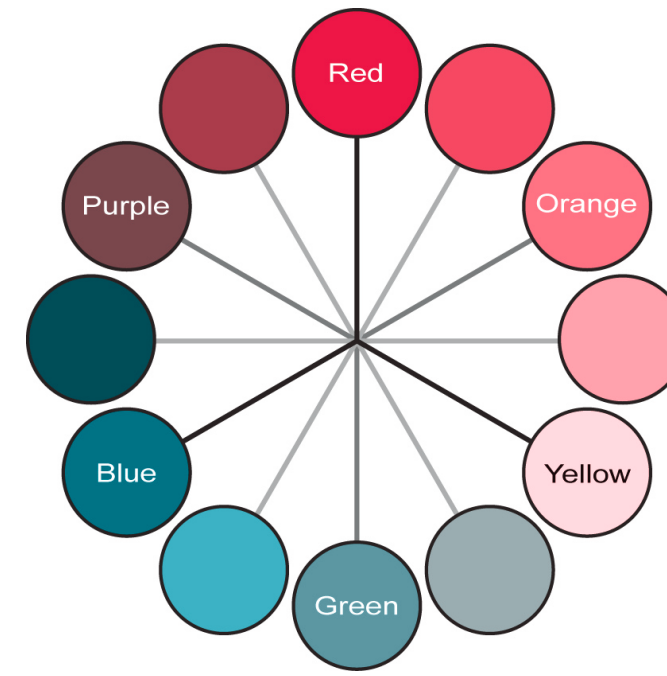
Normal



Protanope



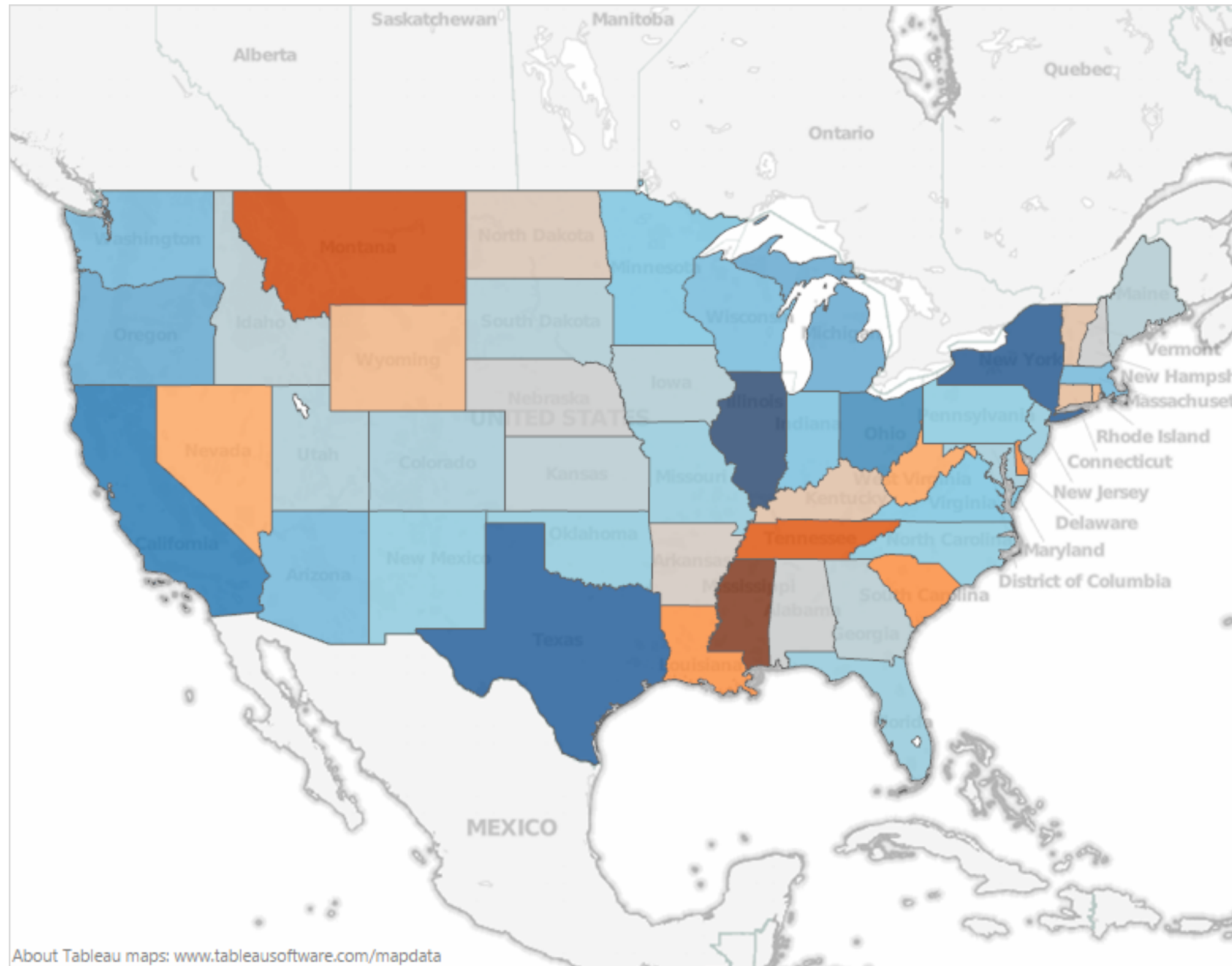
Deuteranope



Tritanope

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

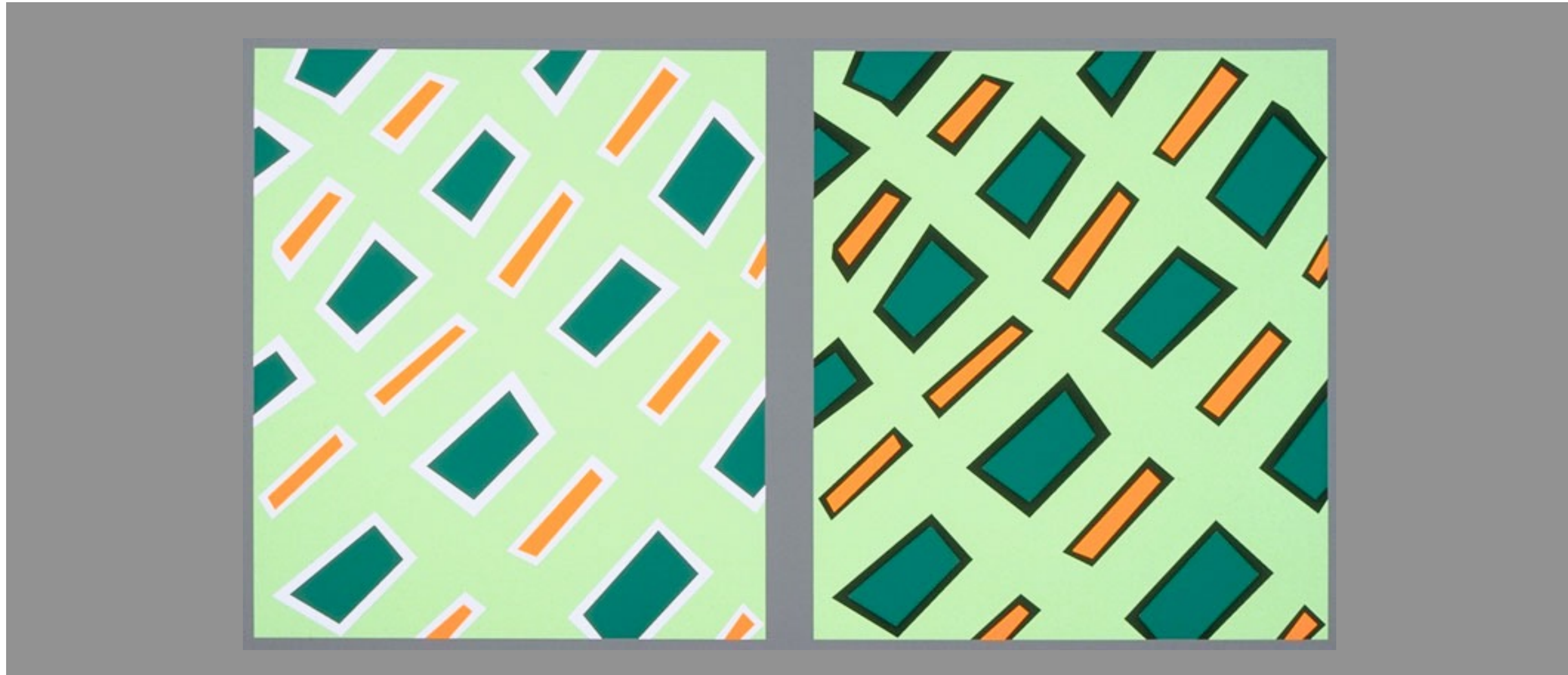
Designing for color deficiency: Blue-Orange is safe



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

Bezold Effect: Outlines matter

- color constancy: simultaneous contrast effect



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

Relative judgements: Color & illumination

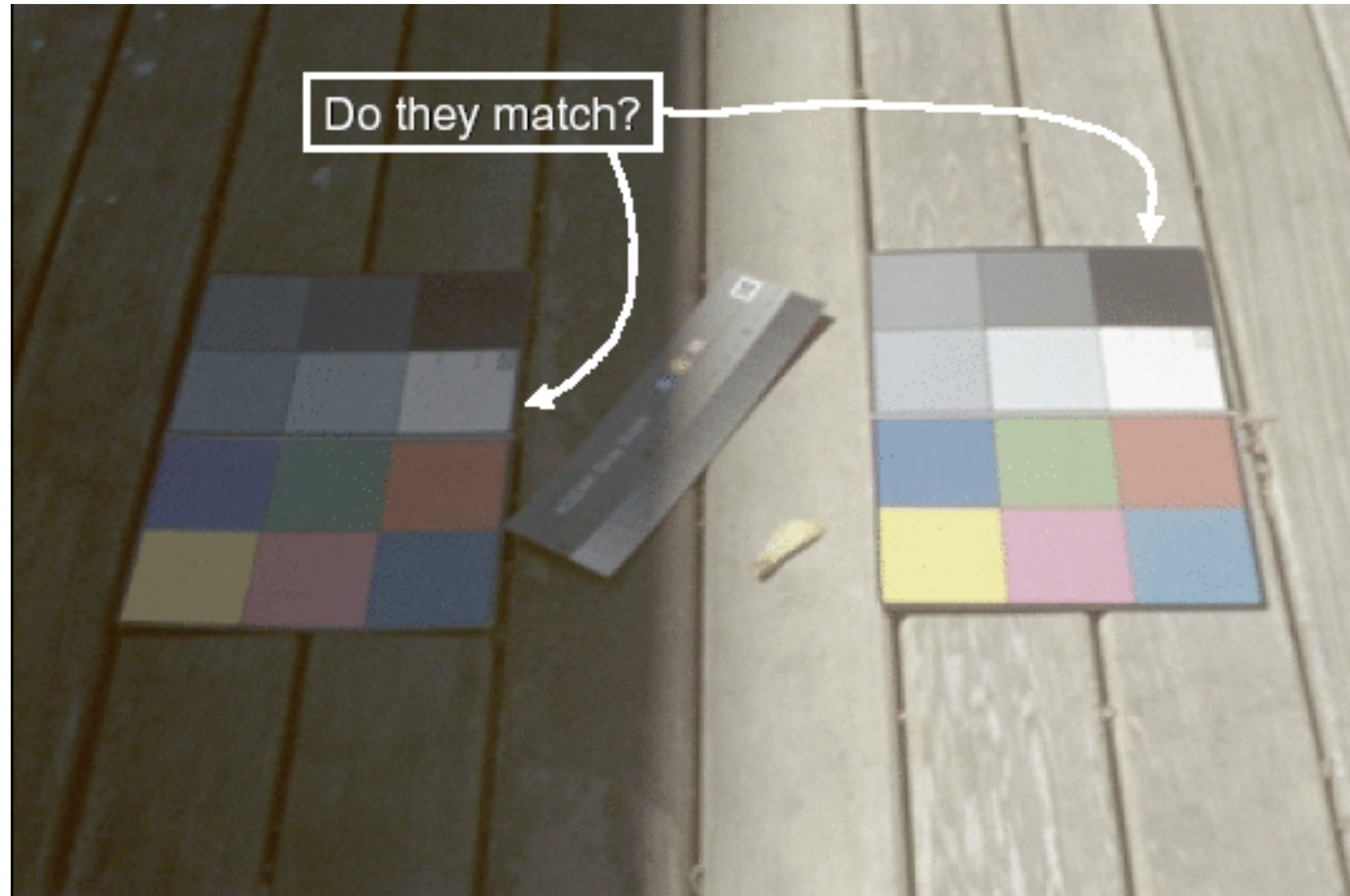


Image courtesy of John McCann

Relative judgements: Color & illumination

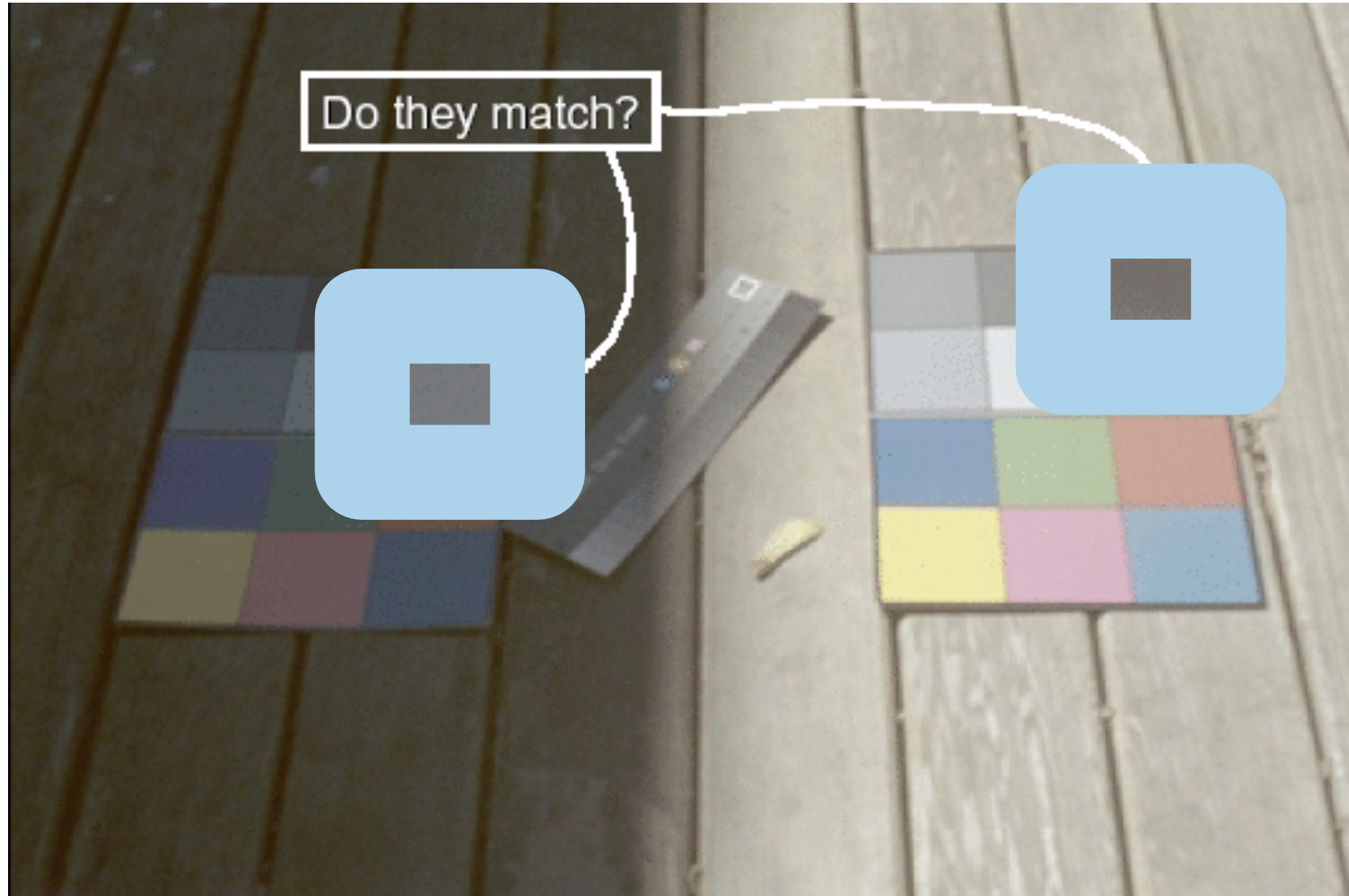
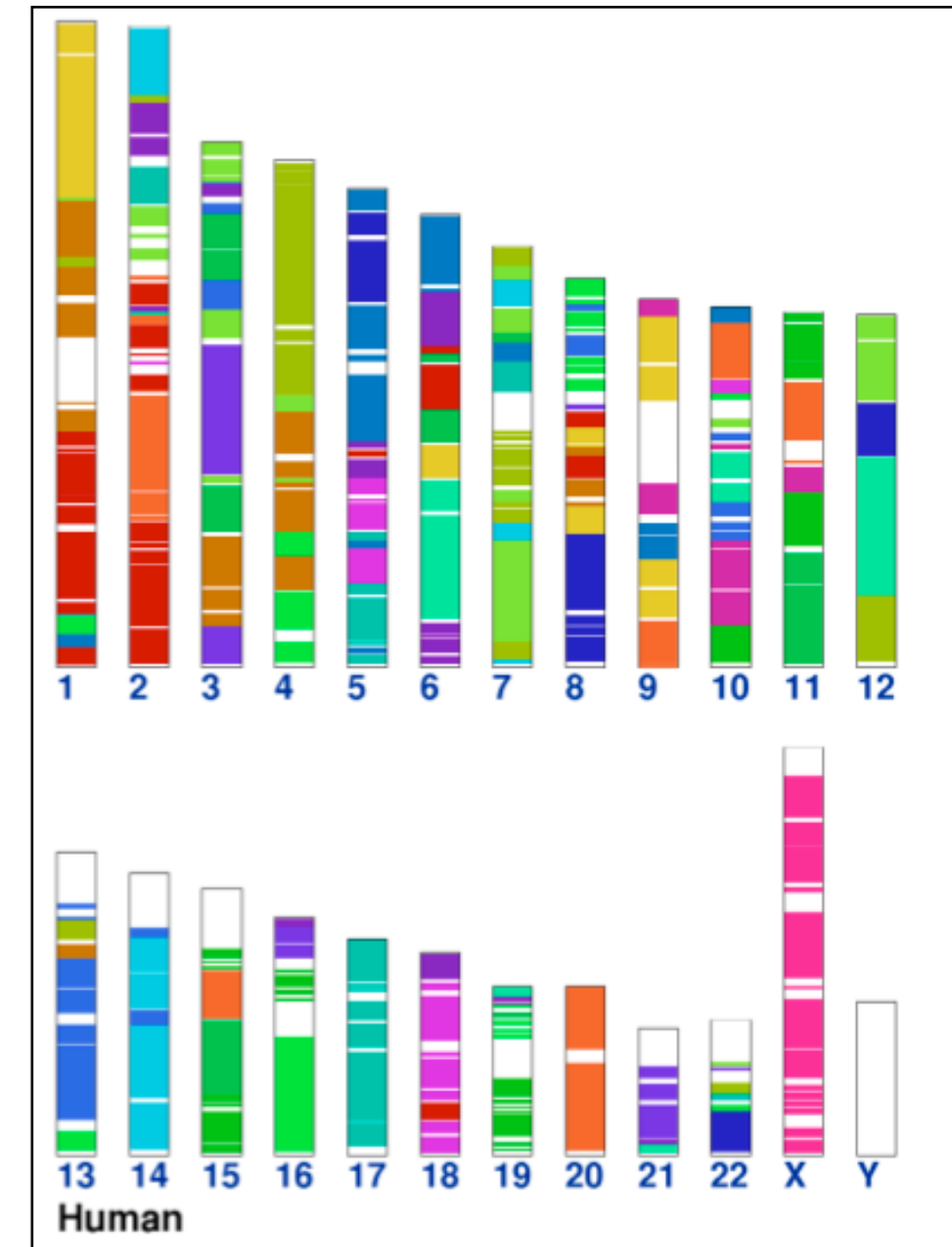
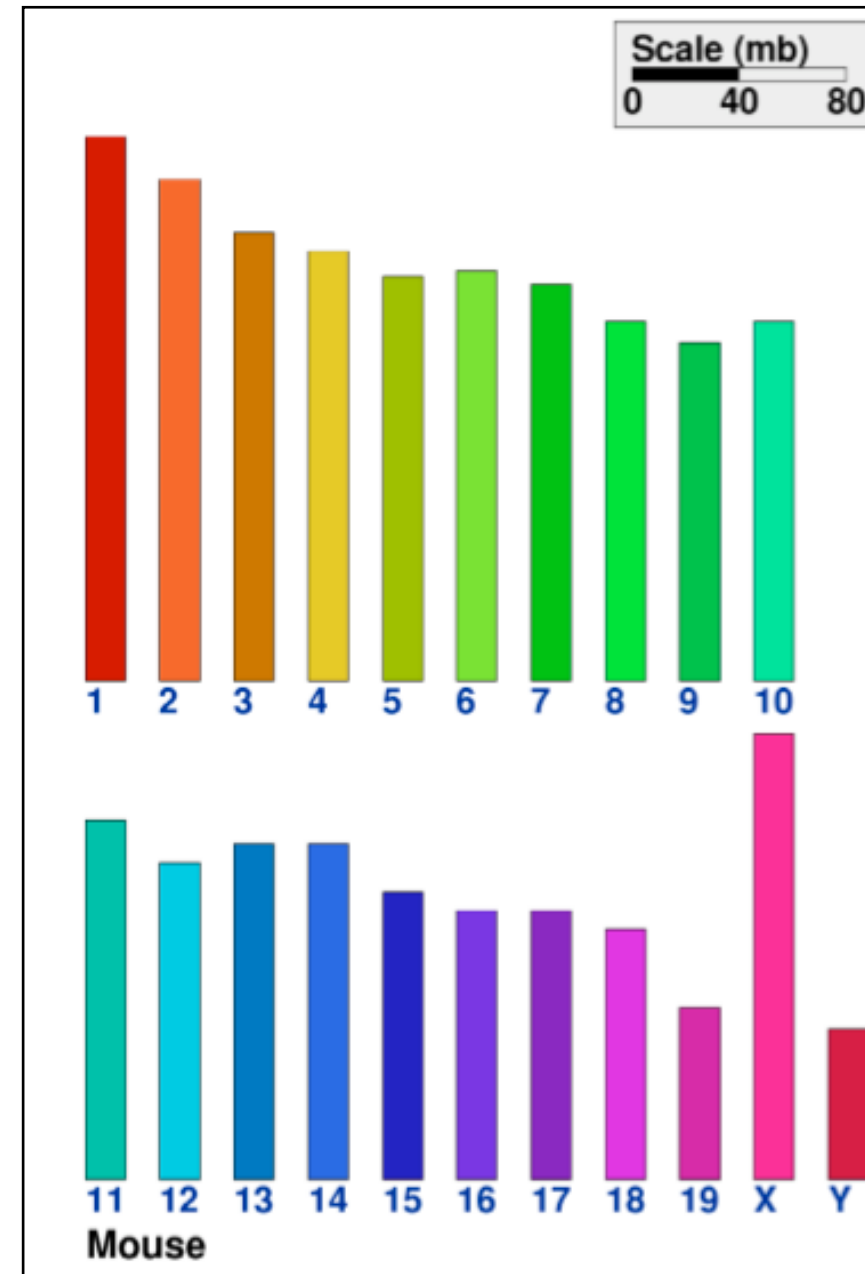


Image courtesy of John McCann via Maureen Stone

Categorical color: limited number of discriminable bins

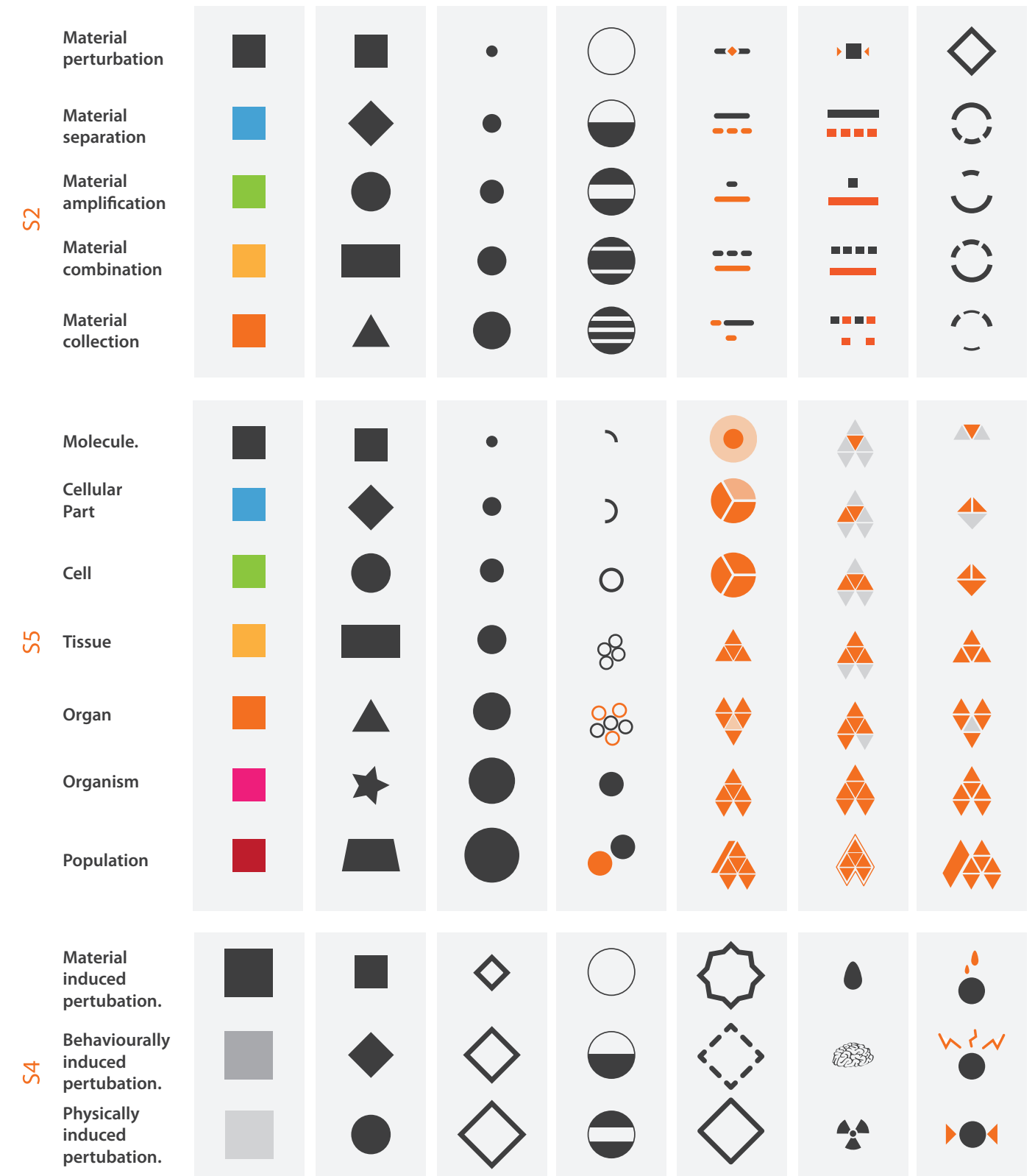
- human perception built on relative comparisons
 - great if color contiguous
 - surprisingly bad for absolute comparisons
- noncontiguous small regions of color
 - fewer bins than you want
 - rule of thumb: 6-12 bins, including background and highlights



[Cinteny: flexible analysis and visualization of synteny and genome rearrangements in multiple organisms. Sinha and Meller. BMC Bioinformatics, 8:82, 2007.]

Glyphs

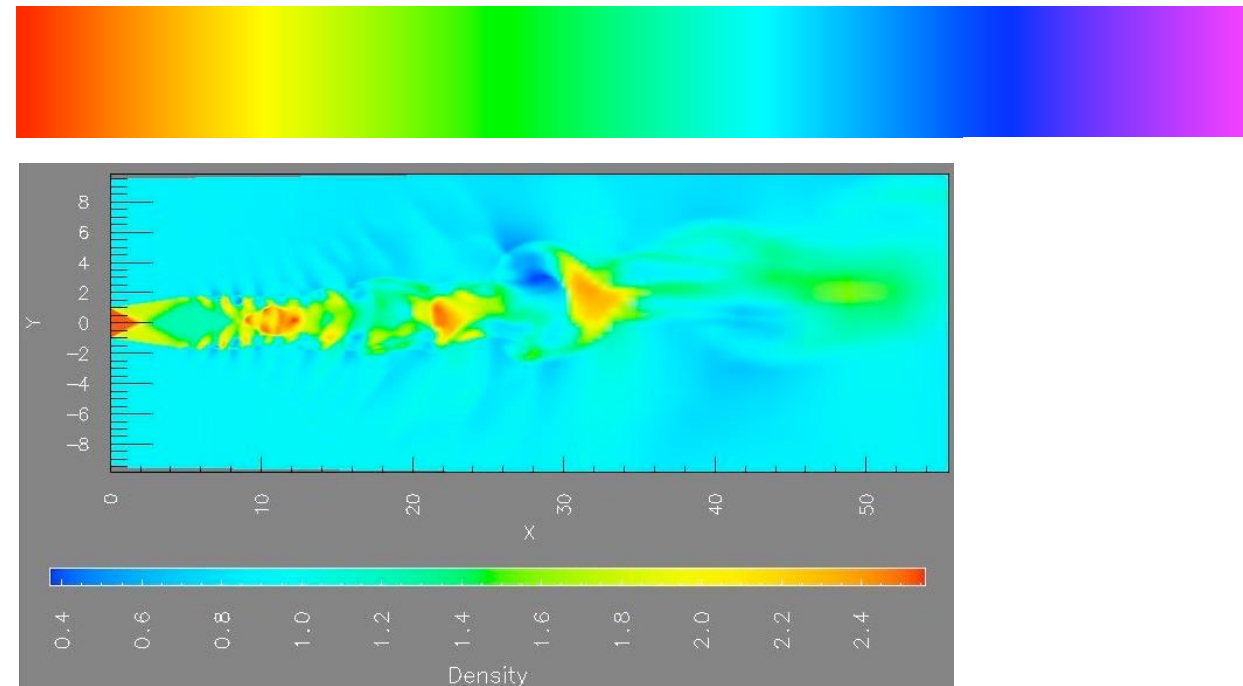
- glyphs: composite objects
 - internal structure with multiple marks
- alternative to color coding
 - or coding with any single channel



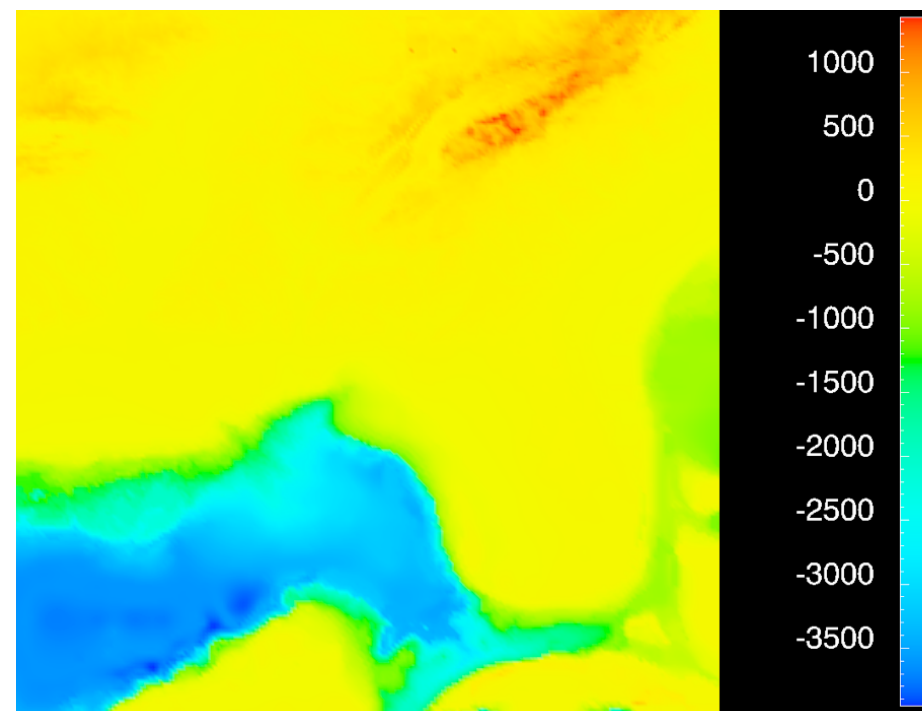
[Fig 5. Taxonomy-Based Glyph Design - with a Case Study on Visualizing Workflows of Biological Experiments.
 Maguire, Rocca-Serra, Sansone, Davies, and Chen. *IEEE Trans. Visualization and Computer Graphics* 18:12:2603-2612 (Proc. InfoVis 12).]

Ordered color: Rainbow is poor default

- problems
 - perceptually unordered
 - perceptually nonlinear
- benefits
 - fine-grained structure visible and nameable



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

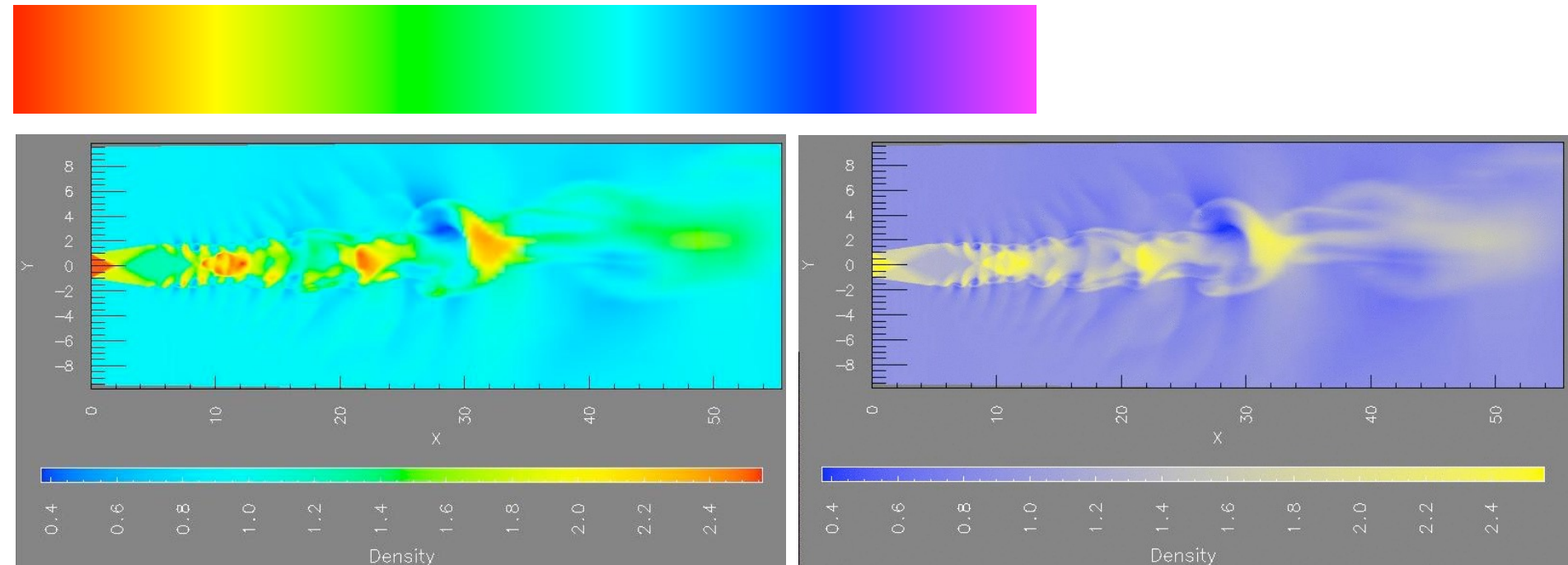


[Why Should Engineers Be Worried About Color? Treinish and Rogowitz 1998. <http://www.research.ibm.com/people/llloyd/color/color.HTM>]

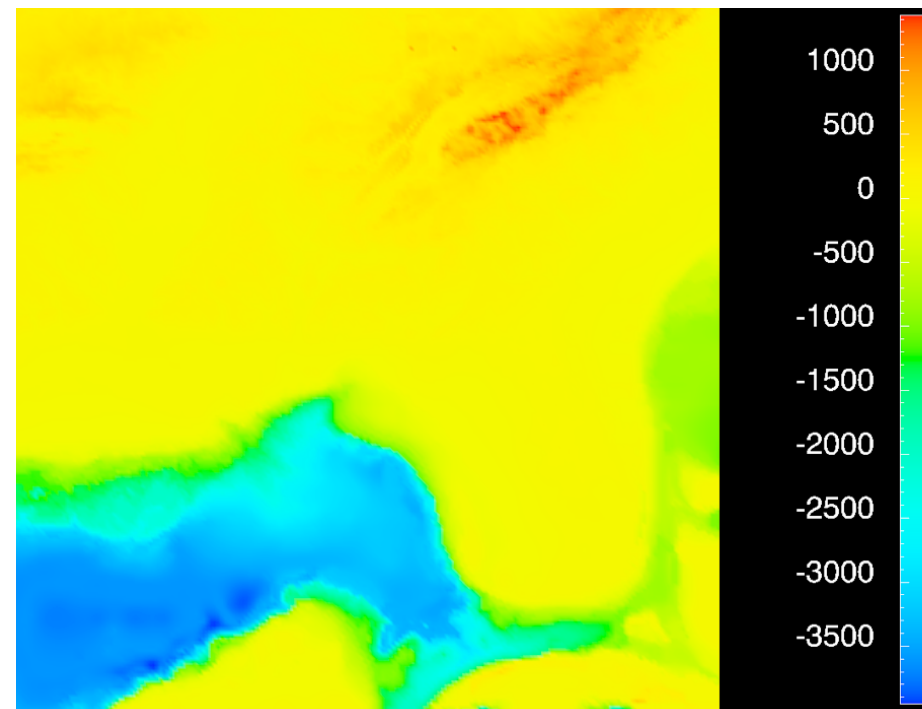
[Transfer Functions in Direct Volume Rendering: Design, Interface, Interaction. Kindlmann. SIGGRAPH 2002 Course Notes]

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 - fine-grained structure visible and nameable
- alternatives
 - large-scale structure: fewer hues



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

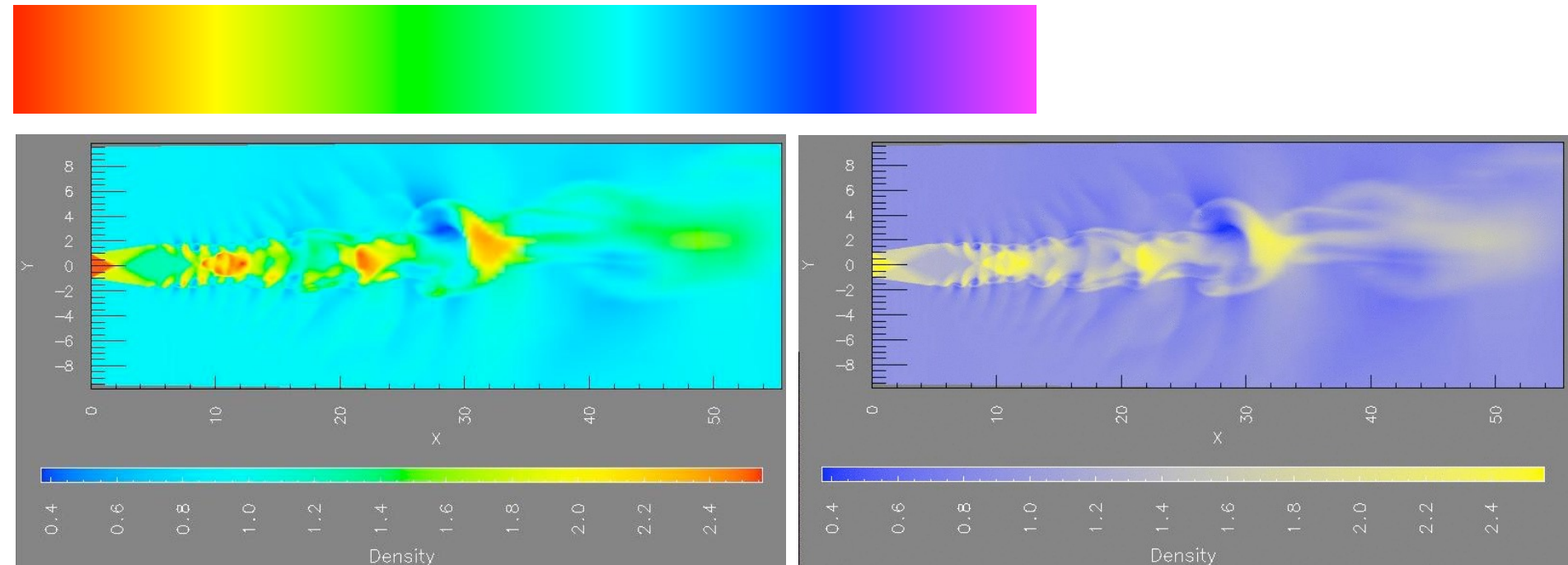


[Why Should Engineers Be Worried About Color? Treinish and Rogowitz 1998. <http://www.research.ibm.com/people/llloyd/color/color.HTM>]

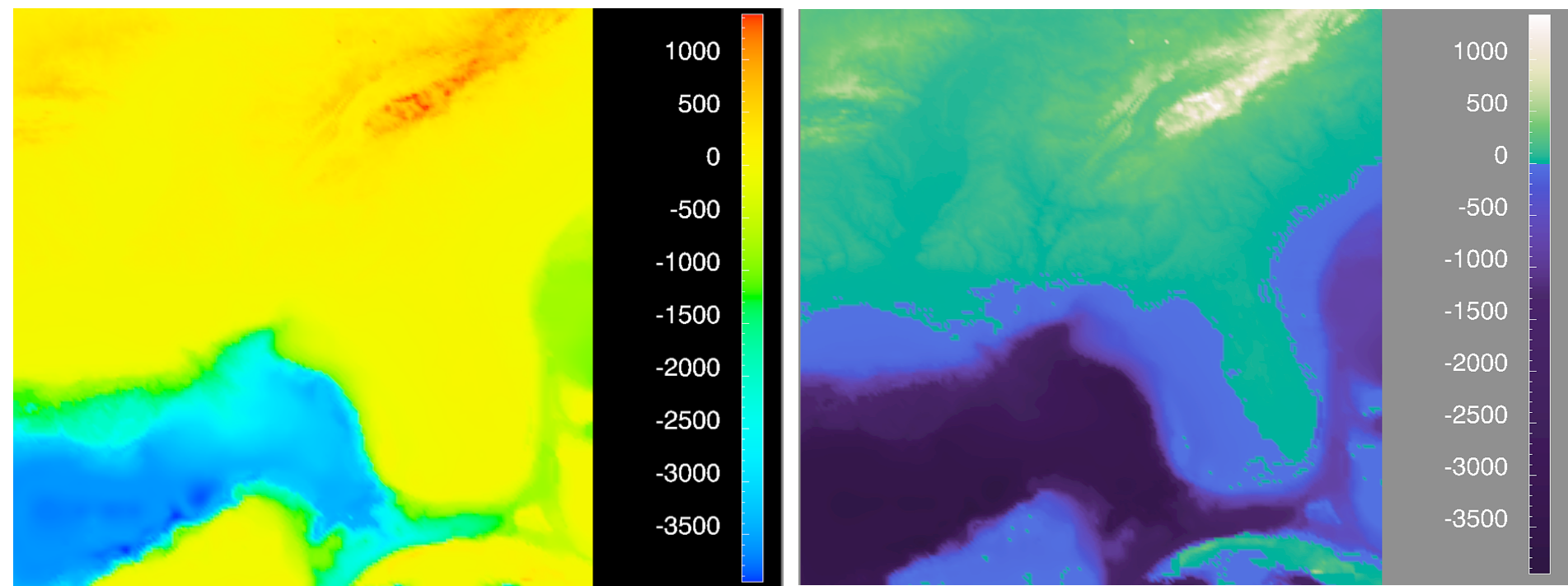
[Transfer Functions in Direct Volume Rendering: Design, Interface, Interaction. Kindlmann. SIGGRAPH 2002 Course Notes]

Ordered color: Rainbow is poor default

- problems
 - perceptually unordered
 - perceptually nonlinear
- benefits
 - fine-grained structure visible and nameable
- alternatives
 - large-scale structure: fewer hues
 - fine structure: multiple hues with monotonically increasing luminance [eg viridis R/python]



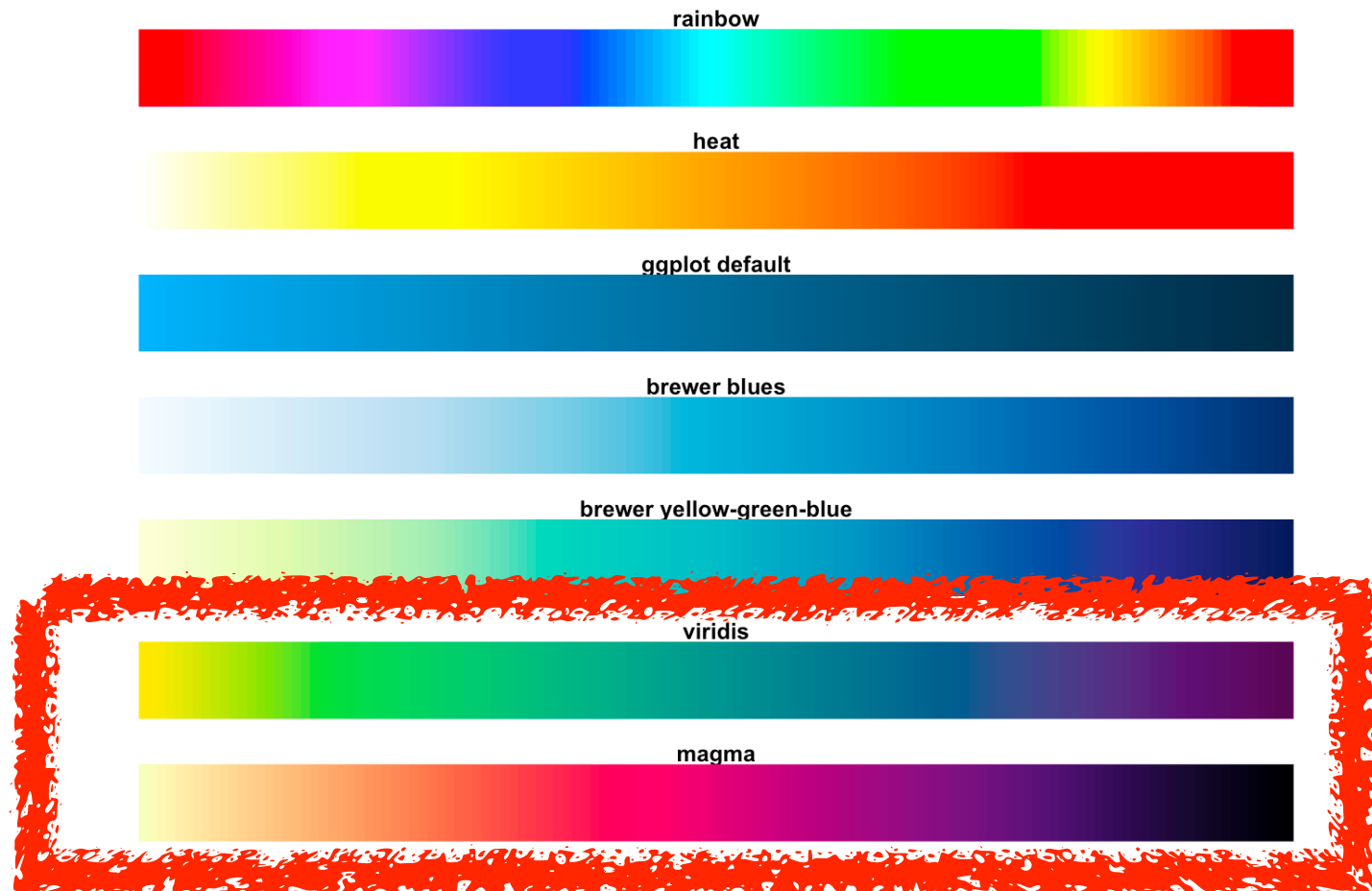
[A Rule-based Tool for Assisting Colormap Selection. Bergman, Rogowitz, and Treinish. *Proc. IEEE Visualization (Vis)*, pp. 118–125, 1995.]



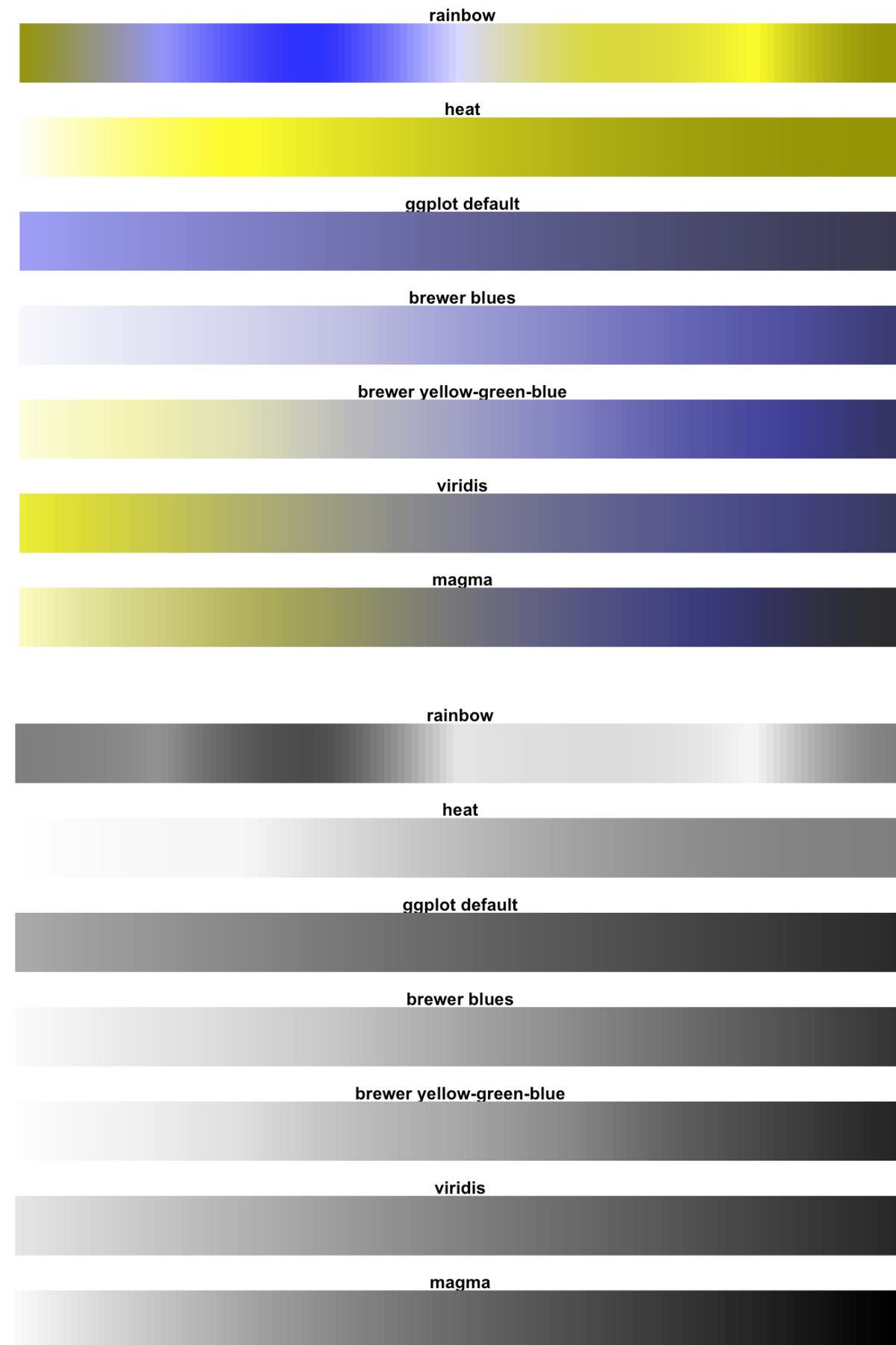
[Why Should Engineers Be Worried About Color? Treinish and Rogowitz 1998. <http://www.research.ibm.com/people/llloyd/color/color.HTM>]

Viridis

- colorful, perceptually uniform, colorblind-safe, monotonically increasing luminance

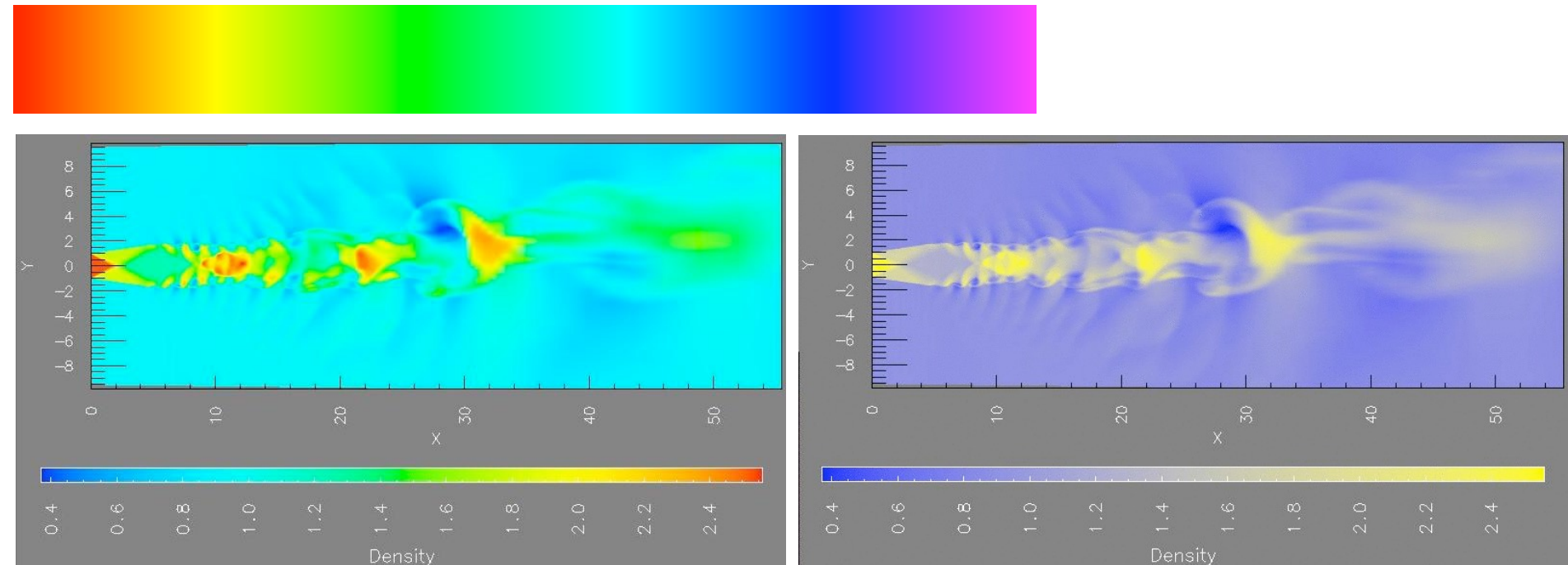


<https://cran.r-project.org/web/packages/viridis/vignettes/intro-to-viridis.html>

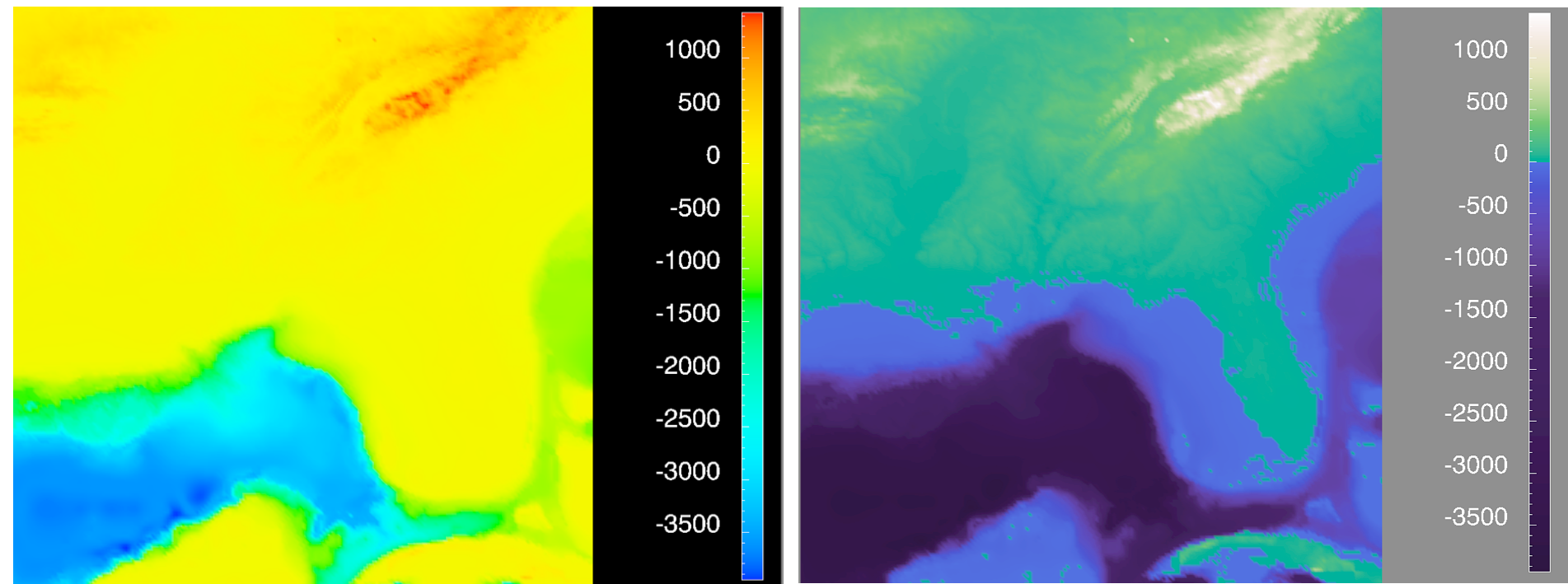


Ordered color: Rainbow is poor default

- problems
 - perceptually unordered
 - perceptually nonlinear
- benefits
 - fine-grained structure visible and nameable
- alternatives
 - large-scale structure: fewer hues
 - fine structure: multiple hues with monotonically increasing luminance [eg viridis R/python]
 - segmented rainbows for binned or categorical



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



[Why Should Engineers Be Worried About Color? Treinish and Rogowitz 1998. <http://www.research.ibm.com/people/llloyd/color/color.HTM>]

[Transfer Functions in Direct Volume Rendering: Design, Interface, Interaction. Kindlmann. SIGGRAPH 2002 Course Notes]

More color resources: Muth

- DataWrapper guidance on color palette creation by Lisa Charlotte Muth
<https://blog.datawrapper.de/create-good-color-palettes/>
 - lots of practical advice, easy to understand

The screenshot shows the top of a web browser displaying the URL blog.datawrapper.de/create-good-color-palettes/. The page header includes the DataWrapper logo, a 'Blog' link, and navigation links for Product, Solutions, Pricing, Resources, Login, and a 'Start creating' button. The article title is 'How to find & create good color palettes' by Lisa Charlotte Muth, dated December 11th, 2024. The article content includes a 'Color in data vis' tag, a '20 min' read time, and a grid of six images illustrating color palette concepts: a hue slider, a color palette with four colors and their hex codes, a line chart with multiple colored lines, a color wheel, a circular color palette, and a hierarchical tree diagram with colored nodes.

If you created a chart, chances are high you now want beautiful, accessible, appropriate colors for it. We already covered [how to pick more beautiful colors for your data visualizations](#) and [what to consider when creating a color palette for your organizational style guide](#). The following article is more practical. It explains which tools and approaches you can use to find, come up with, or extend a color palette:

Where to find good color palettes:

Use the default colors in your tool | Use color palettes created by others for data visualization | Use color palettes created by others | Pick colors from other data visualizations | Pick colors from other works

How to create new color palettes:

Use a tool that generates color palettes for data visualization | Use a palette generator based on the color wheel | Ask an LLM (like ChatGPT or Claude) | Cycle through color palette generators | Pick colors from a gradient | Define lightness and saturation first, then pick the hue | Don't use extra tools

How to extend an existing color palette:

More color resources: Viz Palette

- Viz Palette, by Elijah Meeks and Susie Lu
<https://projects.susielu.com/viz-palette>

- colorblindness checks
- examples for different mark sizes/types
- report on distinguishability including names

The screenshot displays the Viz Palette website interface. The top navigation bar includes the site name 'VIZ PALETTE' by Elijah Meeks & Susie Lu, a search bar, and a 'Finish update' button. The main content area is divided into two primary sections: 'COLORS IN ACTION' and 'COLOR REPORT'.

COLORS IN ACTION

This section features a 'Color Population' selector with options: No Color Deficiency - 96%, Deuteranomaly - 2.7%, Protanomaly - 0.66%, Protanopia - 0.59%, Deuteranopia - 0.56%, and Greyscale. Below this, there are several interactive visualizations: a 'Sample font' showing text in different colors, a 'Randomize Data' button, and a 'Stroke' selector (Dark, None). The visualizations include a horizontal bar chart, a line chart, a scatter plot, and a treemap, all using the selected color palette. A 'Background color' and 'Font color' selector are also present.

COLOR REPORT

This section provides a detailed analysis of the color palette. It includes a legend for 'Arcs link colors difficult to tell apart as:' with categories: Lines or small points, Medium areas, and Large areas. A list of colors is provided with their corresponding names and a note to 'Minimize name conflicts for categorical palettes':

- #ea5f94: pink
- #fa8775: light orange
- #ffb14e: orange
- #ffd700: gold
- #0000ff: indigo
- #cd34b5: magenta
- #9d02d7: magenta

More color resources: Color Buddy

- Color Buddy, by Andrew McNutt and Maureen Stone

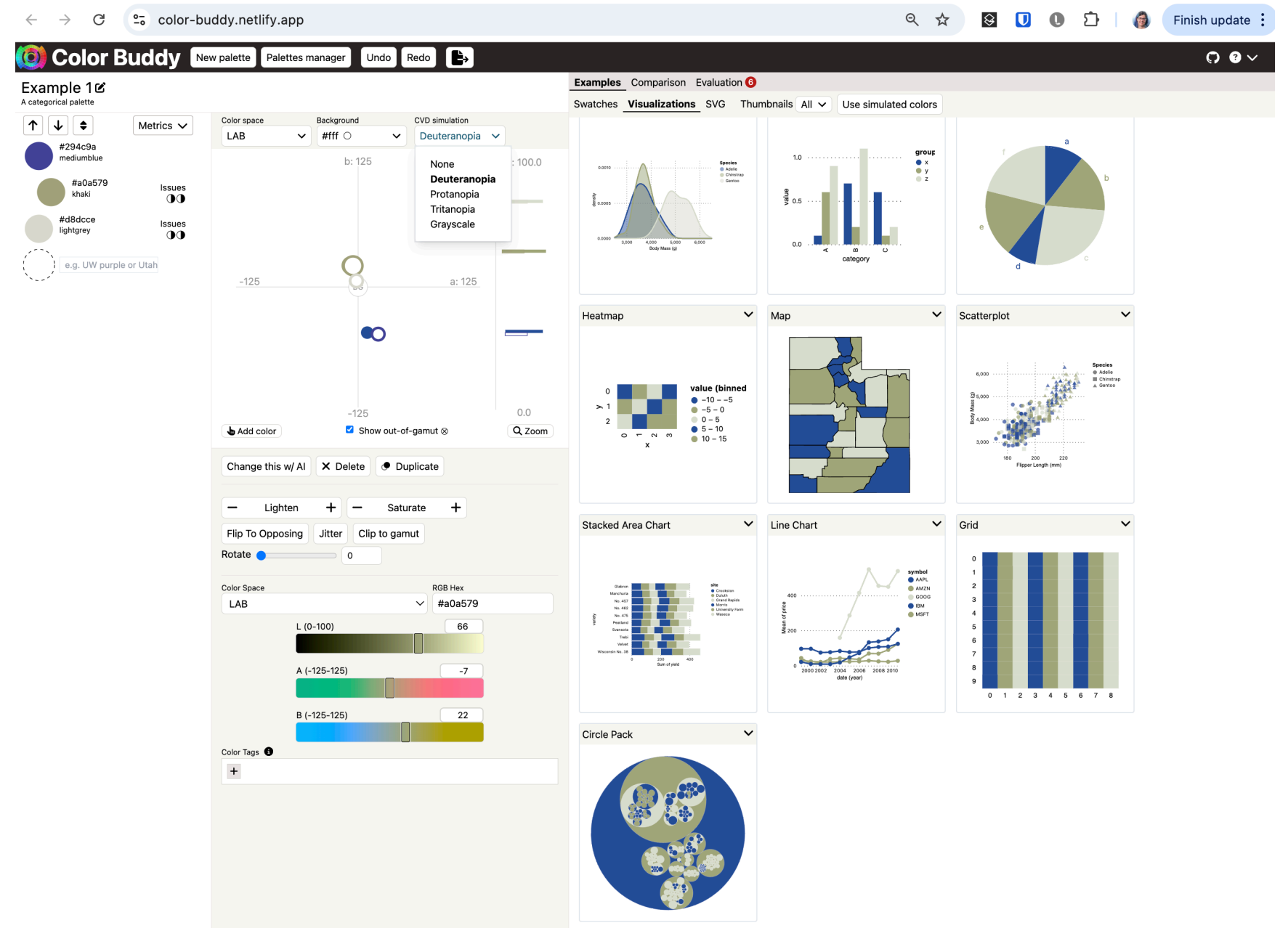
<https://color-buddy.netlify.app/>

- check against colorblindness
- check different mark types/sizes
- evaluate against design guidelines

Examples Comparison **Evaluation 6**

Choose tests Customize tests ?

Usability	Contrast accessibility (WCAG)
✓ Color distinctness: thin-sized objects	✗ AAA text contrast (all colors)
	✗ AA text contrast (all colors)
Color accessibility (CVD)	Design
✓ Right in black and white	✓ Avoid extreme colors
	⚠ Require color complements
	✓ Avoid too much contrast with the background
	✓ Prefer yellowish or blueish greens
	✓ Avoid tetradic palettes
	✓ Background desaturation sufficient
	⚠ Fair
	⚠ Even distribution in lightness
	⚠ Even distribution in hue
	✓ Blue should be high probability for the basic color term blue
	✓ Axes should have low contrast with background



More color resources: Colorgorical

- Colorgorical, by Connor Gramazio
<http://vrl.cs.brown.edu/color>
 - categorical color, including name

Colorgorical

Source

Generate

Number of colors

6

Score importance

Perceptual Distance

Name Difference

Pair Preference

Name Uniqueness

Select hue filters

Drag wheel, or add angle:

to # +

Select lightness range

25 to 85

Add starting colors

#F00, rgb(0,0,0)

+

Results may improve with hue filters or slider changes.

Results:

Color space

Hex

RGB

Lab

LCH

Array format

' ' No quote

Charts

Clear all

["rgb(114,229,239)", "rgb(73,142,148)", "rgb(91,239,143)", "rgb(37,80,38)"]

rgb(114,229,239) + start

rgb(73,142,148) + start

rgb(91,239,143) + start

rgb(37,80,38) + start

Instructions

To generate a palette with n colors, just enter the number of colors you want and click *Generate*. Bigger palettes will take longer than smaller palettes to make. Results will automatically appear when ready.

For greater detail, please consult our [paper](#) or the [source code](#).

Score Importance

Perceptual Distance
Increasing *Perceptual Distance* favors palette colors that are more easily discriminable to the human eye. To accurately model human color acuity, this is performed using CIEDE2000 in CIE Lab color space.

Name Difference
Increasing *Name Difference* favors palette colors that share few common names. This is similar to perceptual distance, but can lead to different results in certain areas of color space. This happens when there are many different names for perceptually close colors (e.g., red and pink are perceptually close but named differently). Colorgorical calculates this using Heer and Stone's [Name Difference](#) function, which is built on top of the [XKCD color-name survey](#).

Pair Preference
Increasing *Pair Preference* favors palette colors that are, on average, predicted to be more aesthetically preferable together. Typically these colors are similar in hue, have different lightness, and are cooler colors (blues and greens). Pair Preference is based off of [Schloss and Palmer's research on color preference](#).

Name Uniqueness
Increasing *Name Uniqueness* favors palette colors that are uniquely named. Some colors like **red** are readily named and are favored, whereas **other colors** are less obviously named and are ignored. Like, Name Difference, Name Uniqueness is based on Heer and Stone's color-name research.

Select hue filter

You can limit which colors are selected by either dragging over the wheel to select a hue range, or by entering the angles manually (e.g., select only reds). You can also make multiple selections after one another to select many different hue ranges (e.g., select both greens and purples).

Select lightness range

You can change whether Colorgorical samples lighter or darker colors by dragging the circles on either end of the lightness range marker.

Add starting colors

You can guarantee that certain colors are in your palette by entering them through the *Add starting palette colors* panel in the menu bar. Make sure that you enter colors one at a time, without quotes, and in either HEX or RGB format. Alternatively, if you generate a palette and want to add a color in it to future generations, click the **+ start** button.

About

Colorgorical was built by Connor Gramazio with advisement from David Laidlaw and Karen Schloss.

Documentation

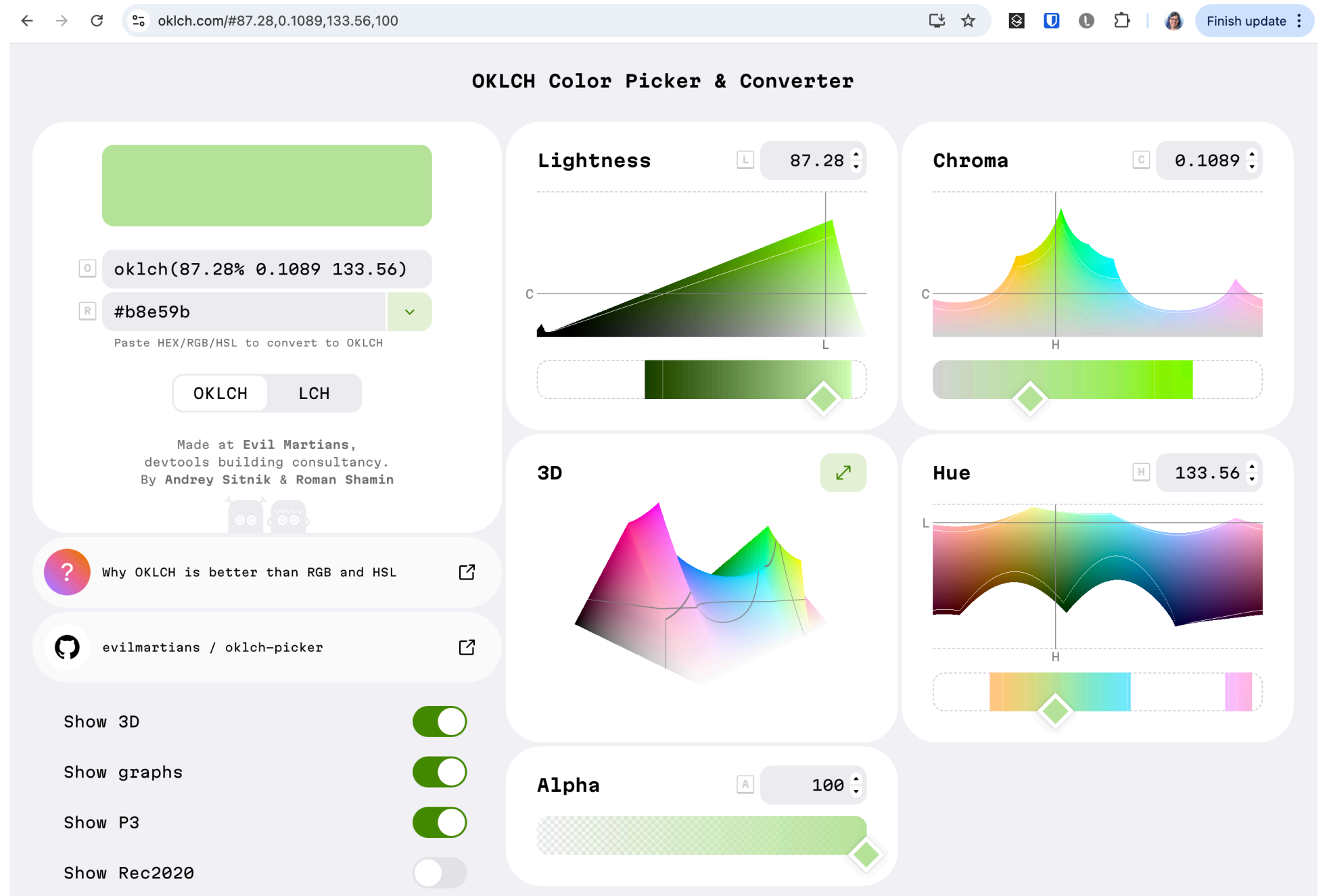
If you'd like to read more about how Colorgorical works, please read our paper [here](#). If you're curious about the implementation, please see the Colorgorical GitHub repository located [here](#).

If you use Colorgorical, please use the following citation:

```
@article{gramazio-2017-ccd,
  author={Gramazio, Connor C. and Laidlaw, David H. and Schloss, Karen B.},
  journal={IEEE Transactions on Visualization and Computer Graphics},
  title={Colorgorical: creating discriminable and preferable color palettes for information vis},
  year={2017}
}
```

More color resources: oklch.com

- oklch perceptual space color picker/converter, by Andrey Sitnik & Roman Shamin (Evil Martians)
<https://oklch.com/>
–inspect color space itself



More color resources: ColorBrewer

- ColorBrewer, by Cynthia Brewer colorbrewer2.com

