Color... part 2

The next few weeks:

- **Homework 5:** Color!
- **Exam 1:** Friday the 2nd
  - There will be no class period
  - I will be online to address technical issues
  - You will have 2 hours* to complete the exam via Submitty once you have first clicked into the gradeable.
    - *Please reach out to me if the school provides you with accommodations
  - The Exam must be completed on Friday
- **Break!** Relax, recharge, and start thinking about your final project
- **Homework 6 (when we come back)**
  - Write up 2x project ideas
  - Post them on the forum
  - Form teams

Homework Assignment 5: Experimenting with Color

Teams of 2 encouraged!

- Revisit an earlier assignment/data/toolkit
  - Make a non-color-related improvement to this visualization
- Prepare many versions of the same visualization experimenting with different color palettes, e.g.:

  - Shades of grey
  - Black & white
  - Cool vs. warm tones
  - Bold/saturated vs. pastel

  - Colorblind aware
  - Light vs dark background and/or color negation
  - Etc.

- Analyze the effectiveness of the color scheme for each visualization.
  - How well does it convey the message? Or mislead the viewer?
- Compare the visualizations to each other.

Today

- Worksheet on Color!
- How to Read a Research Paper
- Components of a Well-written Research Paper
- How to Review a Research Paper
- Readings for Today
  - "Modeling Color Difference for Visualization Design"
    Szafir, IEEE TVCG / IEEE VIS 2017
  - "Optimizing Color Assignment for Perception of Class
    Separability in Multiclass Scatterplots"
    Wang, Chen, Ge, Bao, Sedlmair, Fu, Deussen, and Chen
- Reading for Tuesday
- Accessibility

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How to read a research paper?

(especially an advanced paper in a new area)

- Abstract, conclusion, then the middle
- Read it more than once
- Skim the procedure section (only necessary if you're trying to reproduce)
- Identify the problem, what's a good solution, what's there solution, results
- Look at the figures/tables
- Skim the whole thing, make note of what to come back to
- Read first sentence of every paragraph
- Skip the math, go back to it later
- Print the paper, highlight where the identify the problem, search for where they solve it, search for discussion/future work
- Make notes on acronyms/procedures that are unfamiliar, to minimize scrolling
- Google the topic, if background is unfamiliar (technical jargon can break up your efficiency in reading)
- When you have lots of jargon, slow down, decode what they are trying to say
- Skip the related work if you don't know the area (don't know the authors and papers already)
- Be well rested & awake

How to read a research paper?

(especially an advanced paper in a new area)
- Multiple readings are often necessary
- Don't necessarily read from front to back
- Lookup important terms
- Target application & claimed contributions
- Experimental procedure
- How well results & examples support the claims
- Scalability of the technique (order notation)
- Limitations of technique, places for future research
- Possibilities for hybrid systems with other work

Optional Reading

How to Read a Paper

S. Keshav

David R. Cheriton School of Computer Science, University of Waterloo
Waterloo, ON, Canada
keshav@uwaterloo.ca

http://ccr.sigcomm.org/online/files/p83-keshavA.pdf

Components of a well-written research paper?

- Define all your acronymns
- Clearly state how you used prior work to build your new technique
- Clearly state what problem you are trying to address
- Relevant and supporting images & figures
    - Good captions!
- It's not a mystery novel, no suspense, tell me the answer in the abstract
- Use standard section titles (organized into logical sections, label)
- Good balance of figures and math algorithms and explanation
- Varied examples and tests in the experimental portion (not all the same, test the boundaries/extremes)
- Give justification for your choices (no arbitrary constrants)
- Describe the other techniques that you built upon to create your figures… if your work is part of a whole, describe your contribution and how to reproduce -- what other information/references do you need to do it
- Define what makes a good/ideal solution and why your result/solution is good
    - Evaluate your prior work on the same criteria, explain what needs improvement
- Explain design decisions and constraints on the problem/application
- external/internal validities, is the experiment consistent? Will it be valid in the future
- Accessibility -- audience, don't target too narrowly, not just specialists in your area, people who will actually use
- Comparisons to prior work & other approaches

Components of a well-written research paper?

- Motivation/context/related work
- Contributions of this work
- Clear description of algorithm
  - Sufficiently-detailed to allow work to be reproduced
  - Work is theoretically sound
    (hacks/arbitrary constants discouraged)
- Results
  - well chosen examples
  - clear tables/illustrations/visualizations
- Conclusions
  - limitations of the method are clearly stated

How to review a paper? (constructive feedback to classmates/research peers, or serve on committee to decide paper acceptances)

- Point out things you like & don't like, provide suggestion or reasons, why was it confusing, referenced prior work without sufficient explanation
- Read a paper critically, but also be generously/charitably, don't be a "paper killer"
- Get high level understanding, critique their explanation (constructive feedback)
- Figure out authors' intention -- did they execute that?
- Art critique -- don't say "boring, interesting, good", dig deep, look at specific details, question/admire, more descriptions
- Restate the problem -- ask the author if you got it right
- Better almost if you don't already know the work
- Make sure your feedback is not based on opinion
- Make sure you are sufficiently up-to-date on this topic
- Critique the flow of the paper, is it easy to read
- Make overall note of spelling & grammar (but this is not your "job" usually)

Formal task of paper reviewer (1 of 2)

- Description: Briefly describe the paper and its contribution to computer graphics and interactive techniques. Please give your assessment of the scope and magnitude of the paper's contribution.

- Clarity of Exposition: Is the exposition clear? How could it be improved?

- Quality of References: Are the references adequate? List any additional references that are needed.

- Reproducibility: Could the work be reproduced from the information in the paper? Was any code or data submitted with the supplemental materials? If so, does it support the claims in the paper? Are all important algorithmic or system details discussed adequately in the paper?

Review form for SIGGRAPH

Formal task of paper reviewer (2 of 2)

- Rating: Please rate this paper on a continuous scale from 1 to 5, where:
  - 1 = Definitely reject. I would protest strongly if it's accepted.
  - 2 = Probably reject. I would argue against this paper.
  - 3 = Possibly accept, but only if others champion it.
  - 4 = Probably accept. I would argue for this paper.
  - 5 = Definitely accept. I would protest strongly if it's not accepted.

  Please base your rating on the paper as it was submitted.
- Reviewer Expertise: Please rate your expertise in the subject area of the paper on a continuous scale from 1 to 3, where:
  - 1=Beginner
  - 2=Knowledgeable
  - 3=Expert
- Explanation of Rating: Explain your rating by discussing the strengths and weaknesses of the submission, contributions, and the potential impact of the paper. Include suggestions for improvement and publication alternatives, if appropriate. Be thorough. Be fair. Be courteous. Your evaluation will be forwarded to the authors during the rebuttal period.
- Private Comments: You may enter private comments for the papers committee here. These comments will not be sent to the paper author(s). Please do not mention any other papers that are currently in review, or the names of people associated with these papers.

Review form for SIGGRAPH

Read eventually...

How NOT to review a paper
The tools and techniques of the adversarial reviewer

Graham Cormode
AT&T Labs–Research
Florham Park NJ, USA
graham@research.att.com[*]

https://sigmodrecord.org/publications/sigmodRecord/0812/p100.open.cormode.pdf

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Reading for Today:

"Modeling Color Difference for Visualization Design"
Szafir, IEEE TVCG / IEEE VIS 2017
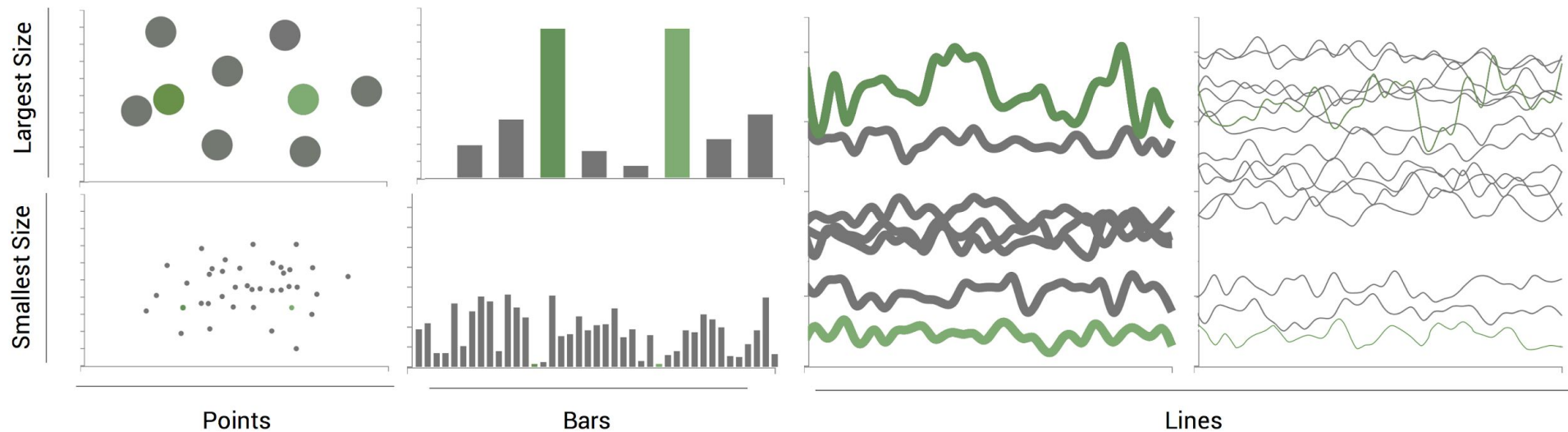
- JND: just noticeable difference, discriminability
- Perceived color difference varies inversely with size
  - Due to our visual system, elongated marks easier to distinguish
  - If noticeable difference is not adjusted, will be more conservative than necessary when choosing colors
  - Visual field degree / pixels
- Assumptions: Simple world vs. uncalibrated display, isolation vs. complex visualization, size/shape geometry
- Experiments
  - Use Mechanical Turk
  - Are these 2 colors different?
    (plotted as data surrounded by other dots/bars/lines of grey)
  - Mixed factors, mixed participants,
  - Fatigue effect
  - Significance of results, ANCOVA
- Colors for visualization "where data is known at design time"
  - e.g., "data journalism" uses fixed datasets

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Readings for Today *pick one*

- "Optimizing Color Assignment for Perception of Class Separability in Multiclass Scatterplots", Wang, Chen, Ge, Bao, Sedlmair, Fu, Deussen, and Chen, IEEE InfoVis 2018.
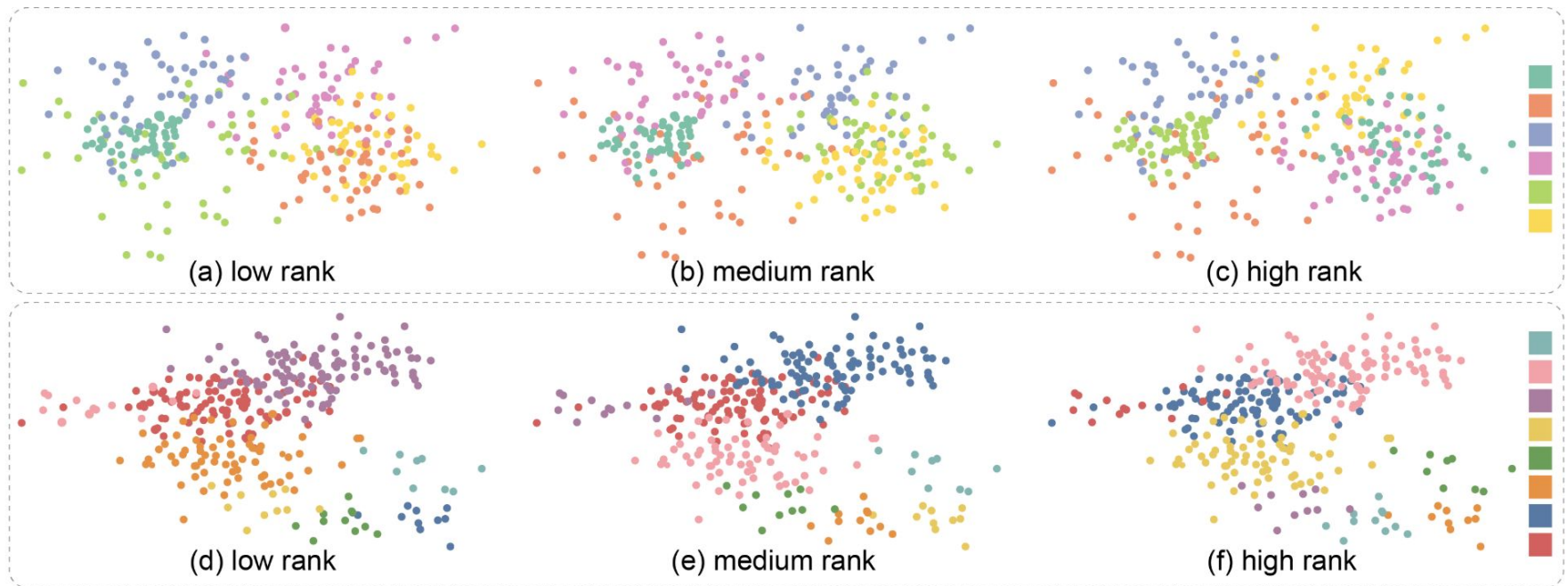
Figure 1: The color assignment has a strong influence on the visual separability of class structures shown in multiclass scatterplots. Here we show synthetically labeled six-class (top row) and eight-class (bottom row) datasets, and color palettes from ColorBrewer (a,b,c) and Tableau (d,e,f). Scatterplots are displayed from left to right using color assignments produced by our method with the lowest (i.e., poor) scores ranked by our separation measure (a,d) towards the one with the highest (i.e., best) scores (c,f).

Reading for Today

- Labeled Data: Has marked categories
- Color Assignment Problem:
  - Can we automatically label semantically?
  - Can we automatically label via rules?
- What rules?
  - "Colors should be well separated"
  - "Colors should cooperate with one another"

Visual Salience

- … is the perceptual quality that makes some items in the world stand out from their neighbors and grab our attention
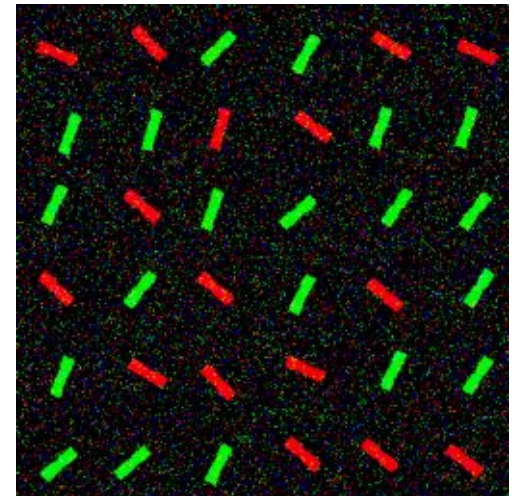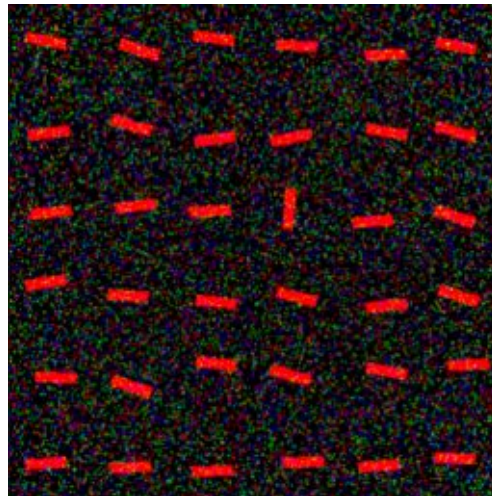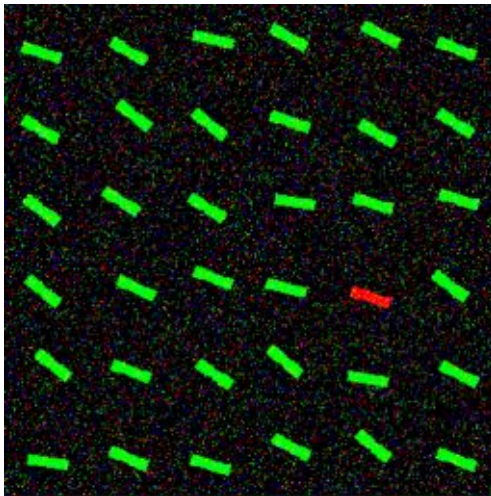
- Designers use saliency to create objects (such as this emergency triangle) that appear highly salient in a wide range of viewing conditions

Interesting Read:

An automatic generation of schematic maps to display Flight Routes for Air Traffic Controllers: Structure and color optimization. Hurter et al.
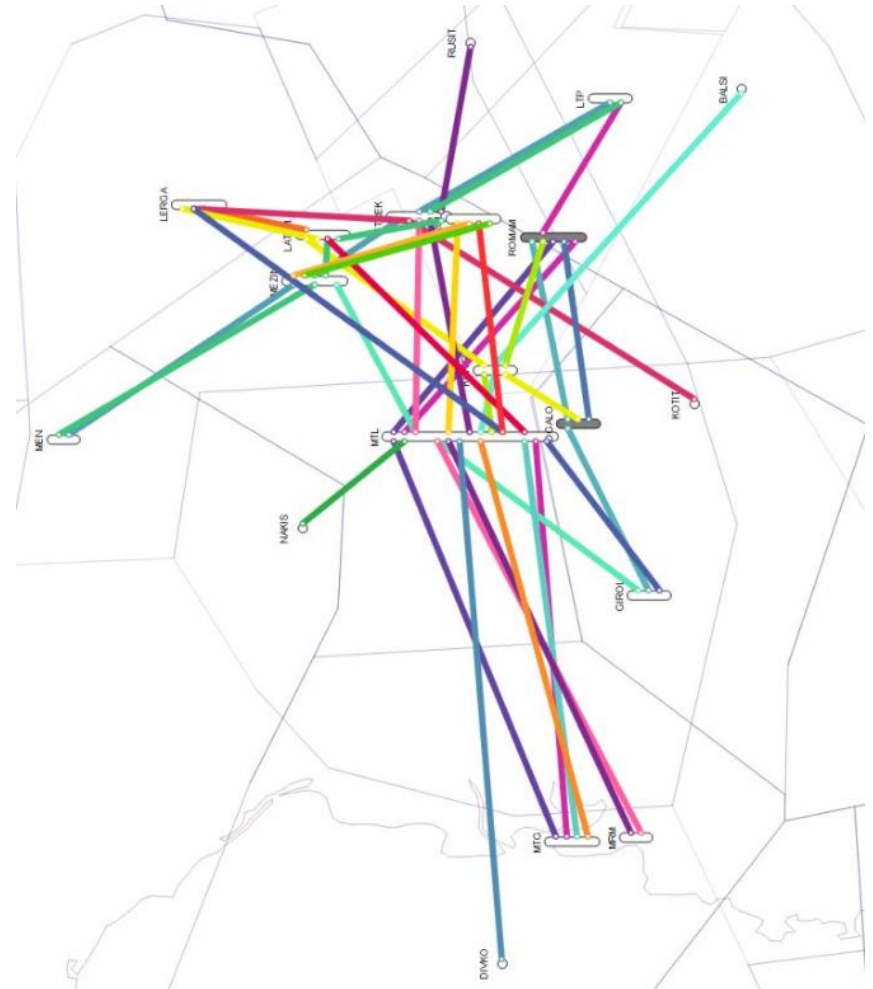

Figure 5 : View with no geographical optimization and with the

Reading for Today

- Authors note that saliency has 2 parts:
  - Points vs one another
  - Points vs the background
- What should the weights be?
  - Authors utilize "KNNG" K-nearest neighbors algorithm with k = 2
    - Extended to report nearness of the nodes
- How do we tell how close two colors are?
  - An easy way is to map them into a coordinate plane (i.e., a 3D color space) and take the distance
 - CIE also has a number of distance measures

Genetic Algorithm

- *If you can't figure out a smarter optimization method…*

- Encode a potential problem solution as a sequence
  - *Each sequence must be same length, with a consistent meaning to the value at each location in the sequence*

- Keep a group of your *k* best-*ish* solutions
- Try different random variations of that group
  - Swapping random subsequences (crossover)
    - *This only makes "sense" if neighboring locations in the sequence are related (not fully independent)*
  - Randomizing a single location (mutation)

Genetic Algorithm

- How do we know what a good result looks like?
  - An Objective Function!

- In this paper:

  - Maximize the sum of the separation degree of all points in each class.
- Parts of a genetic algorithm:
  - **Selection:** Some fit individuals survive (Lottery?)
  - **Crossover:** Good "DNA" is passed on/shuffled between two parents and their offspring
  - **Mutation:** Random mutation stops us from stalling at local maxima
  - **GA Parameters:** Everything needs tuning!

process τ_j

$\cdots$

process τ_i

Parents

Children

(a)   (b)   (c)   (d)
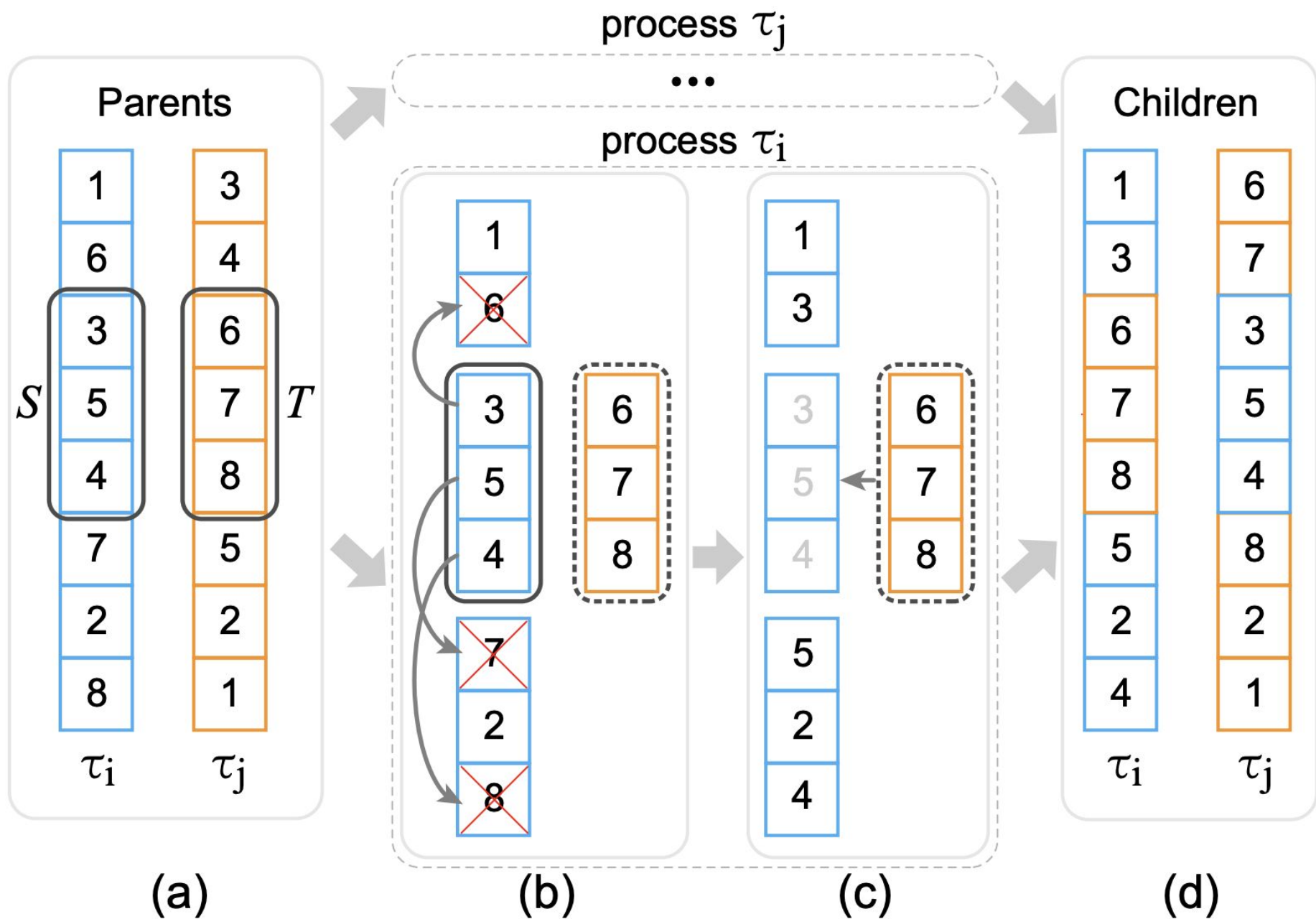
Reading for Today

Questions: How many classes are there? A/B testing.

Studies

- Pilot Study:
  - Confounding factors:
    - Easy to learn the visualizations
    - People sometimes chose at random
- Core Study
  - Difficult visualizations: people liked authors' work
  - The algorithm doesn't take harmony into account
- Expert Comparison
  - The algorithm is capable of producing expert output

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    Wang, Chen, Ge, Bao, Sedlmair, Fu, Deussen, and Chen
  - A few more interesting papers
- Reading for Tuesday
- Accessibility

Reading for Today: *(choose one)*

"A Linguistic Approach to Categorical Color Assignment for Data Visualization", Setlur and Stone, IEEE InfoVis 2015
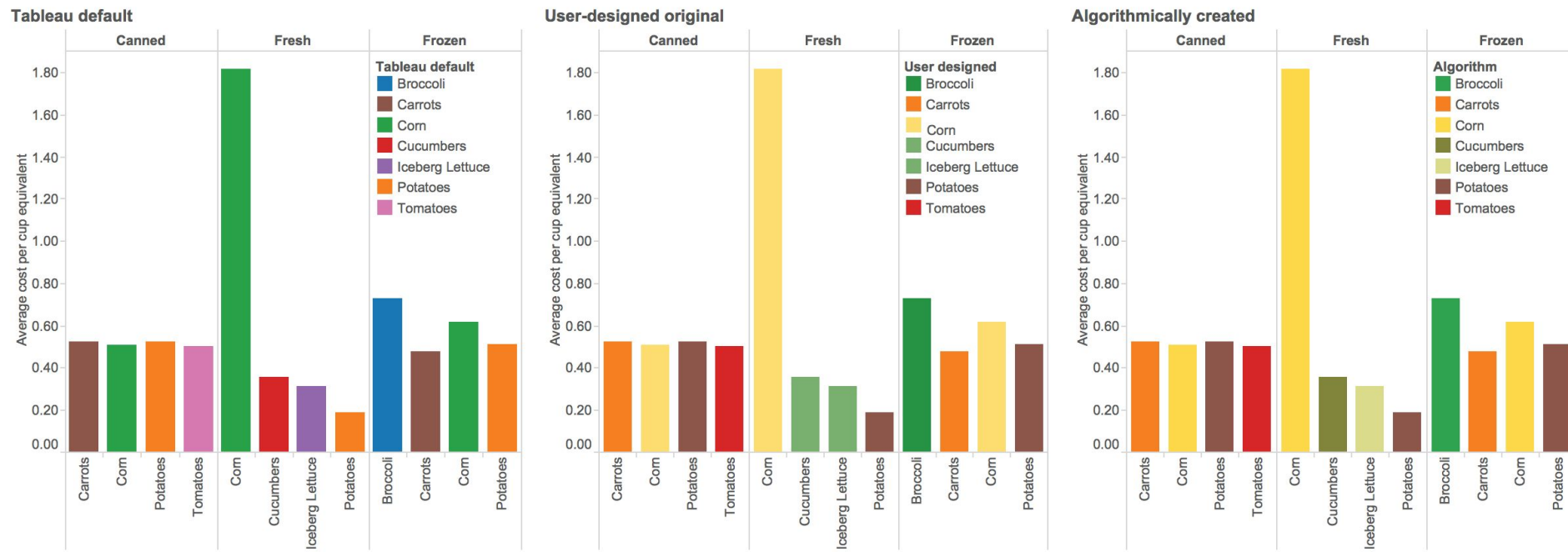
Fig. 1. This visualization was taken from a Tableau Public workbook [11] to illustrate the value of semantic color encoding. Left: The Tableau default colors are perceptually legible, but conflict with the data semantics ('Tomatoes' are pink, 'Corn' is green). Center: The Tableau author matched the colors to the data semantics (red for 'Tomatoes', yellow for 'Corn'), which makes it easier to identify the different types of vegetables in the graph. Right: Our algorithm automatically created a similarly effective result.
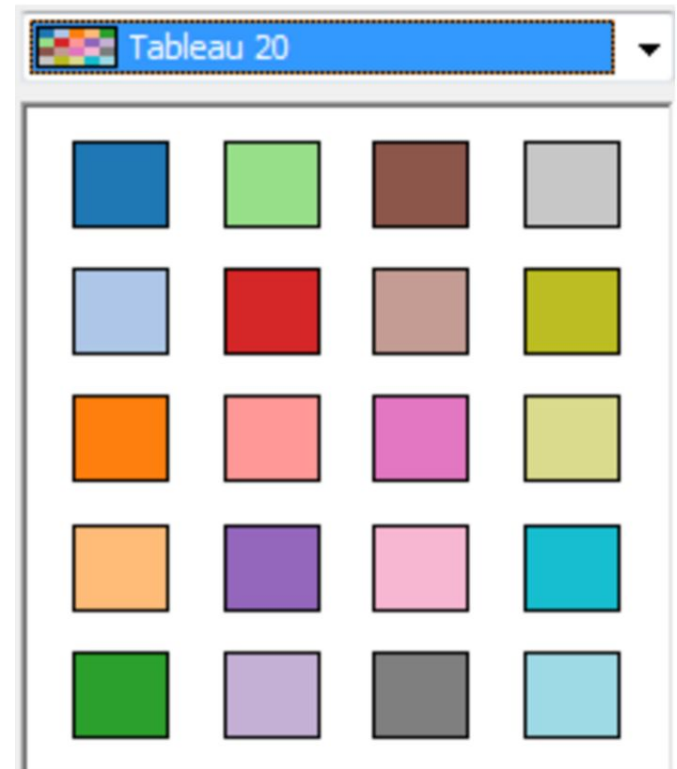
Stroop Effect
http://faculty.washington.edu/chudler/words.html

TableauColors

Musell Color System
http://www.codeproject.com/Articles/7751/
Use-Direct-D-To-Fly-Through-the-Munsell-Color-So
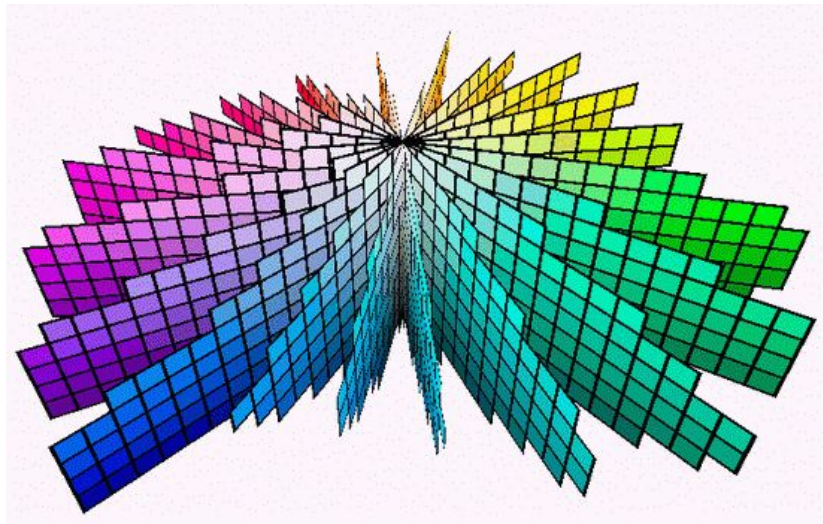
- Is a word colorable?
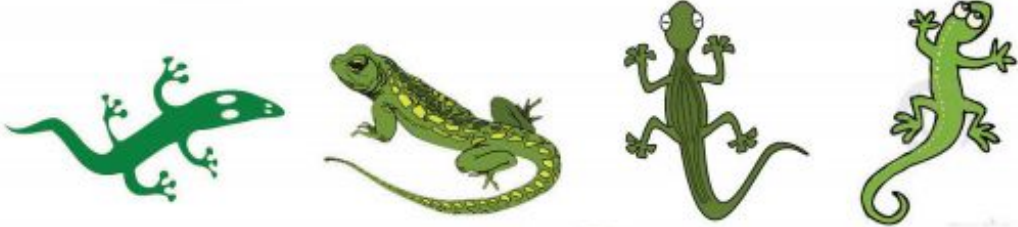 - Use Google n-grams to find # of times it is associated with color (books only? Would this be even better if they had a general human speech corpus?)
  - Are there strong color associations for a word?
- What is the best color value?
  - google images (clipart or natural images?)
- Semantic context
  - apple the fruit or apple the company?
  - NLP (Natural Language Processing)
- K-means clustering to create set of distinct colors (flexibility of different colors for some items)
- *"The power of these names is not their accuracy, but their memorability and ease of use."*

- Berlin & Kay's 11 basic color terms:
  - black, white, red, green, yellow, blue, brown, purple, pink, orange, gray
- Why clipart?

Input term	Top clustered images	Canonical color
taxi		
lizard		
saffron		

- Query expansion, Ontology, Concept tree

- Not surprised that it performs poorly for logos
- Even if the results are always perfect, this can be a huge timesaver! And expand what colors we should consider.
  - Why limit choices to Tableau 20? Why not pantone? Or Munsell?
- Good scientific organization to paper
- Larger datasets & statistics always(?) better than surveys
  - Presented algorithms are entirely dependent on these datasets
- Impressive result for 2 different fields (could alternatively be a paper in an NLP conference)
- Lots of detail in the paper (good for reproducibility)… but also feels like lots of padding/redundancy in the paper? (same example used multiple times)
- Discussion could be stronger/more complete
  - Competitor's results often (always?) seemed better…
- Xkcd is awesome
- Sentiment analysis (sorta creepy)
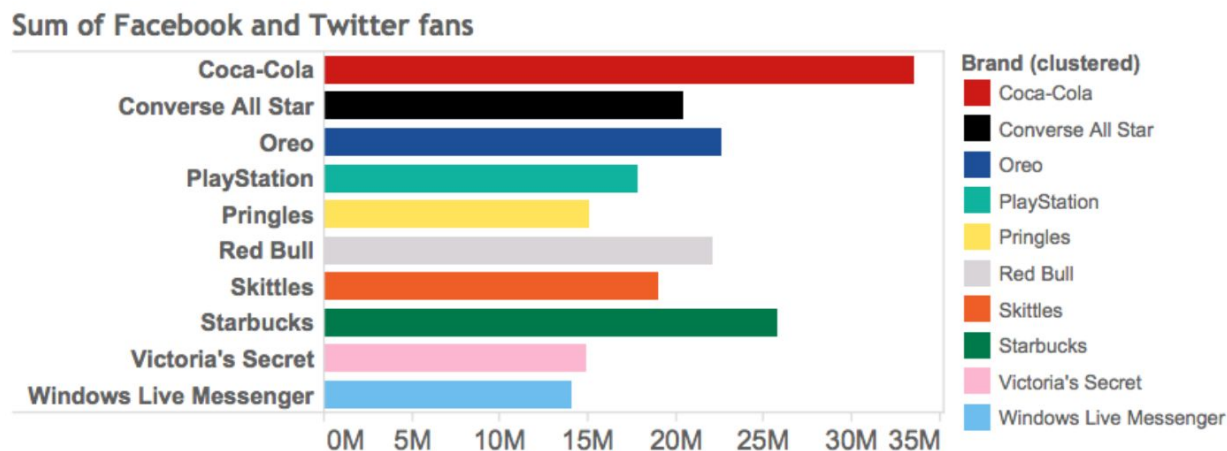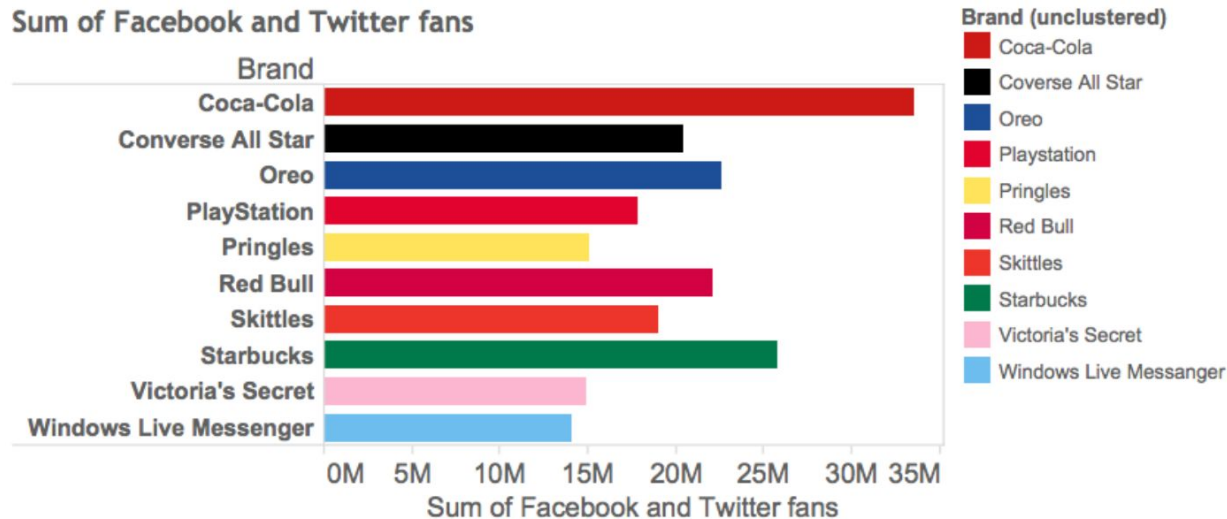- Why include poem?

Fig. 12. Top row: A Tableau Public visualization [11] semantically color encoded with our algorithm before clustering is applied. One can observe several brands colored with shades of red. Bottom row: Once clustering is applied to the set of colors, some of the reds are replaced by alternate canonical colors obtained from the corresponding logo images.

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- Reading for Tuesday
- Accessibility

Reading for Tuesday:

- "Stacked Graphs – Geometry & Aesthetics"
  Lee Byron & Martin Wattenberg, IEEE TVCG 2008
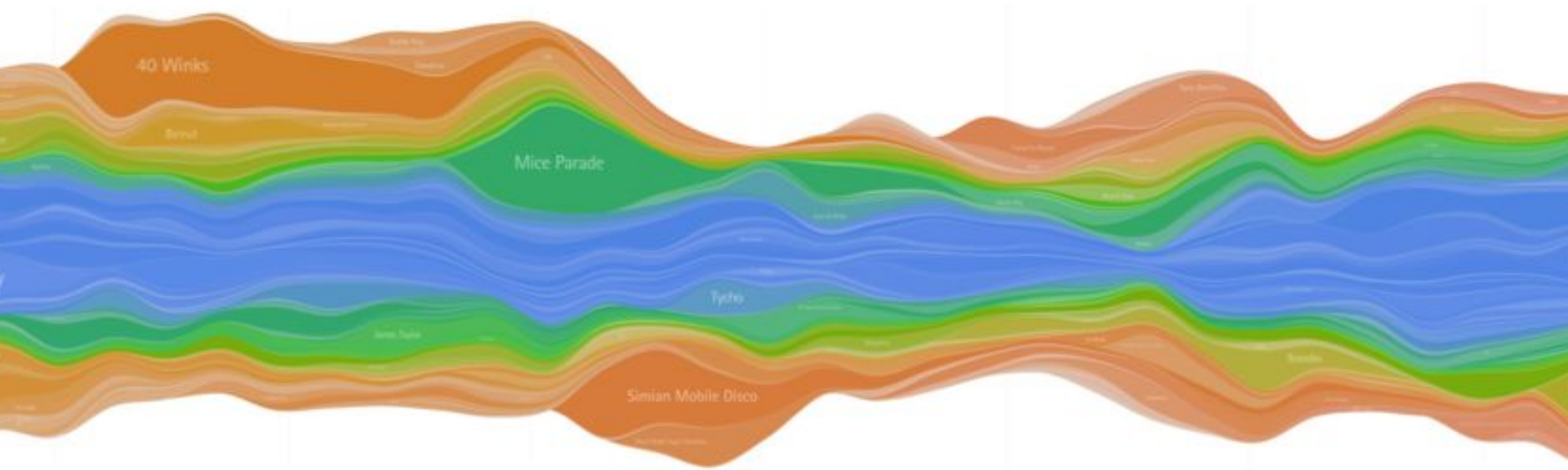
a.k.a. *Streamgraphs*

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Accessibility

- What is it?
  - "When websites and web tools are properly designed and coded, people with disabilities can use them." W3.org
- WebAIM: Web Accessibility in Mind
  - A major standard provider in web accessibility
- WCAG: Web Contrast Accessibility Guidelines
  - Specifically for visually impared individuals
  - (But it makes it easier for everyone else to see too!)

WCAG

- Three levels
  - A, AA, and AAA
  - All websites should strive for AA
  - Government sites may require AAA
- What is a contrast ratio:
  - Ratio of the luminance (brightness) of the lightest shade to the darkest shade
- Small text and large text have different requirements

Tools to make it easier

- Lighthouse!
  - Automatic audits of your site to find accessibility problems
  - Also helpful if you want to deploy a Progressive Web App (PWA)
- WAVE
  - Cross browser automatic web accessibility testing
- Web inspector
  - Selecting web elements shows you their contrast
- Web Color Picker
  - Shows lines for AA and AAA

More reading

- The Science of Color Contrast
  - https://medium.muz.li/the-science-of-color-contrast-an-expert-designers-guide-33e84c41d156
- WebAIM
  - https://webaim.org/articles/visual/
- Submitty Accessibility Guidelines
  - https://submitty.org/developer/interface_design_style_guide/web_accessibility
  -

Reading for Today: *(choose one)*

"Hue-Preserving Color Blending"
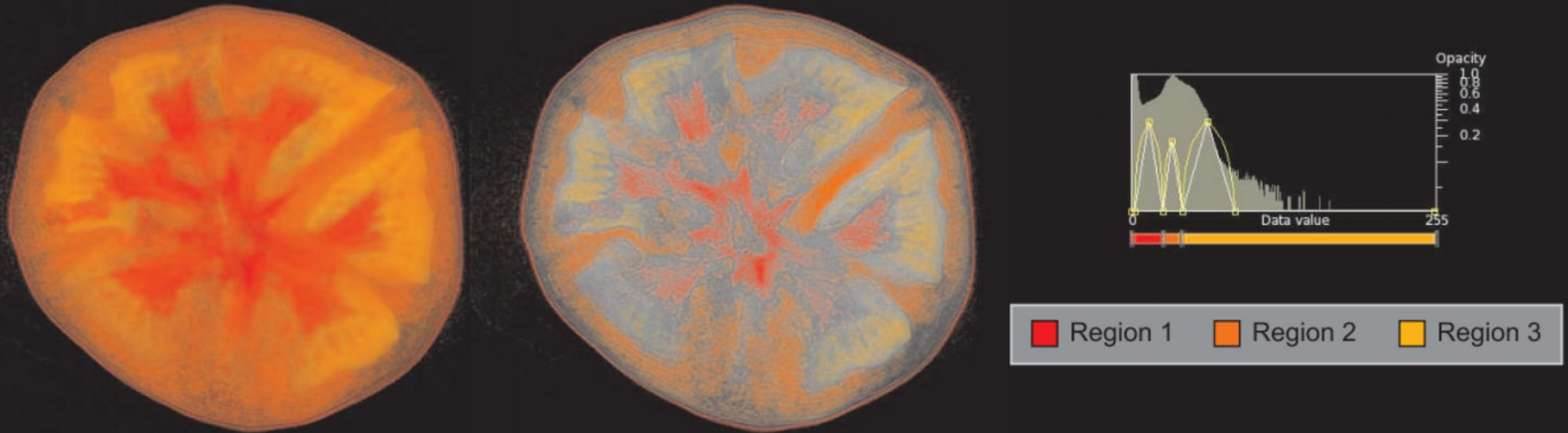Chuang, Weiskopf, and Möller, TVCG 2009

Fig. 1. Volume rendering of a tomato data set using traditional (left) and hue-preserving (middle) color blending. The data histogram, transfer function, and color legend are shown on the right.

- Color is particularly effective for visual grouping
- Volume visualization classifies data into material components -> want to visualize these regions
  - Great potential for application to medical data

- Opposite colors should be used for semi-transparent layers to avoid hue shift after alpha blending
  - Just a small change in the traditional method
  - No change (if colors are already opposite), or
  - More significant change (forcing blend through gray)

- Clearly states:
  - Observations (from perception research),
  - Design criteria (wants), and
  - Requirements (compromise of wants)
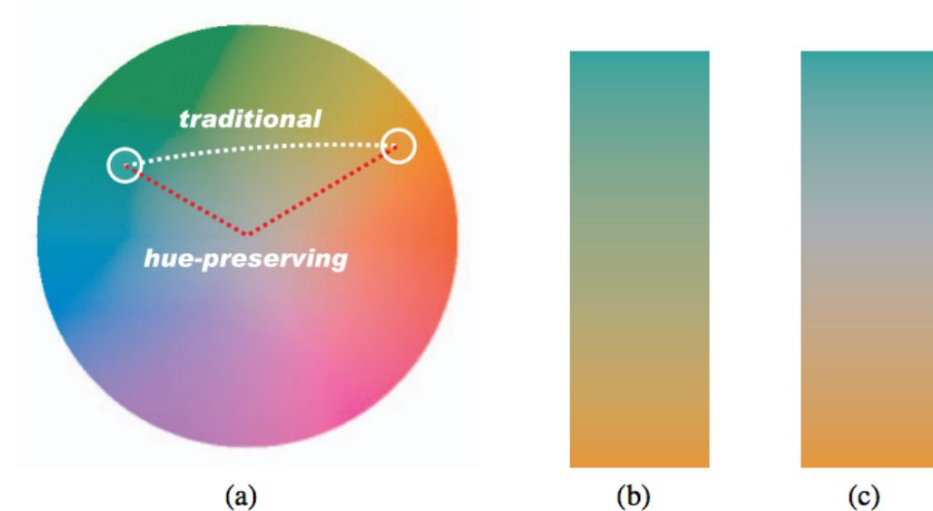
Region 4 = eyes
(only the eyes
should be orange)

| Region 1 | Region 2 | Region 3 | Region 4 | Region 5 |
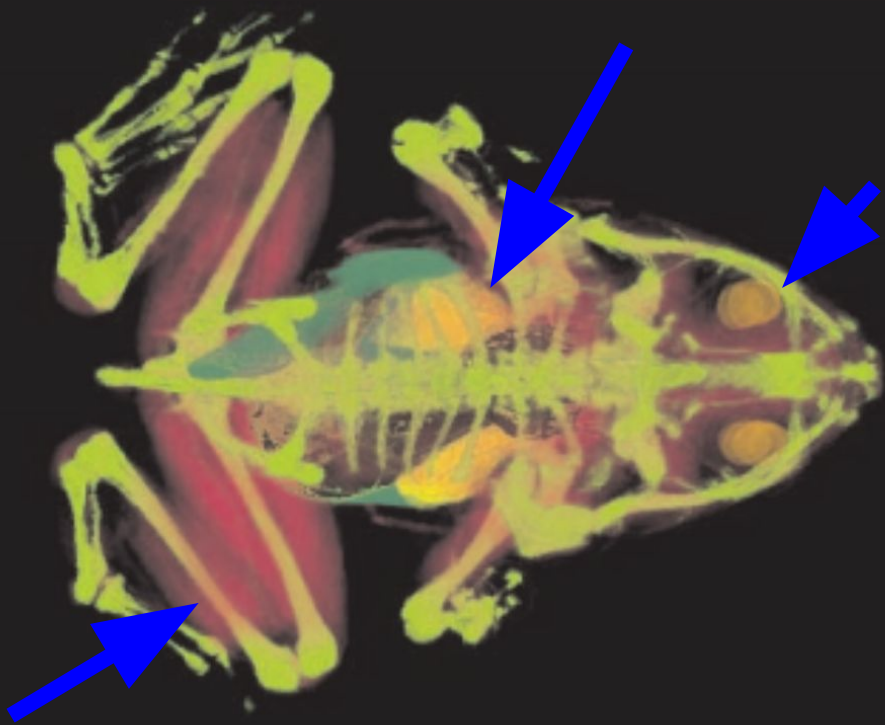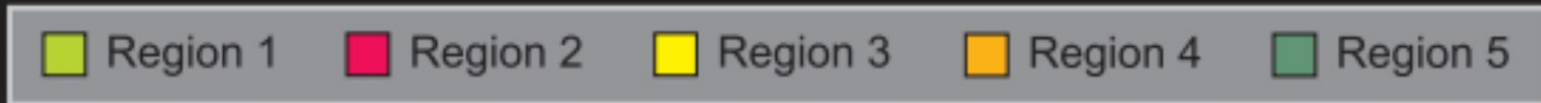
original
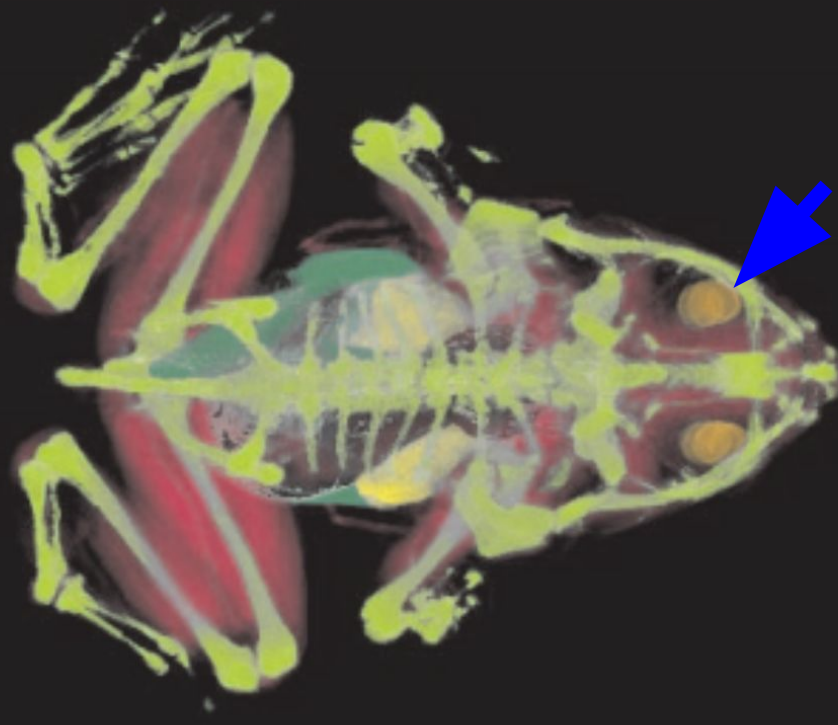
hue preserving

- Example images were very well chosen
- "when using many colors of different hues, I get a blended hot mess of color that completely washes out and detail of the underlying 3D rendered model"
- Long sections could be broken up with subsection titles
  - limitations/drawbacks is buried in the middle of "results" (not enough attention paid to negatives?)
- The Matlab "jet" color scheme is the default (and it looks so pretty!), but it is misleading!
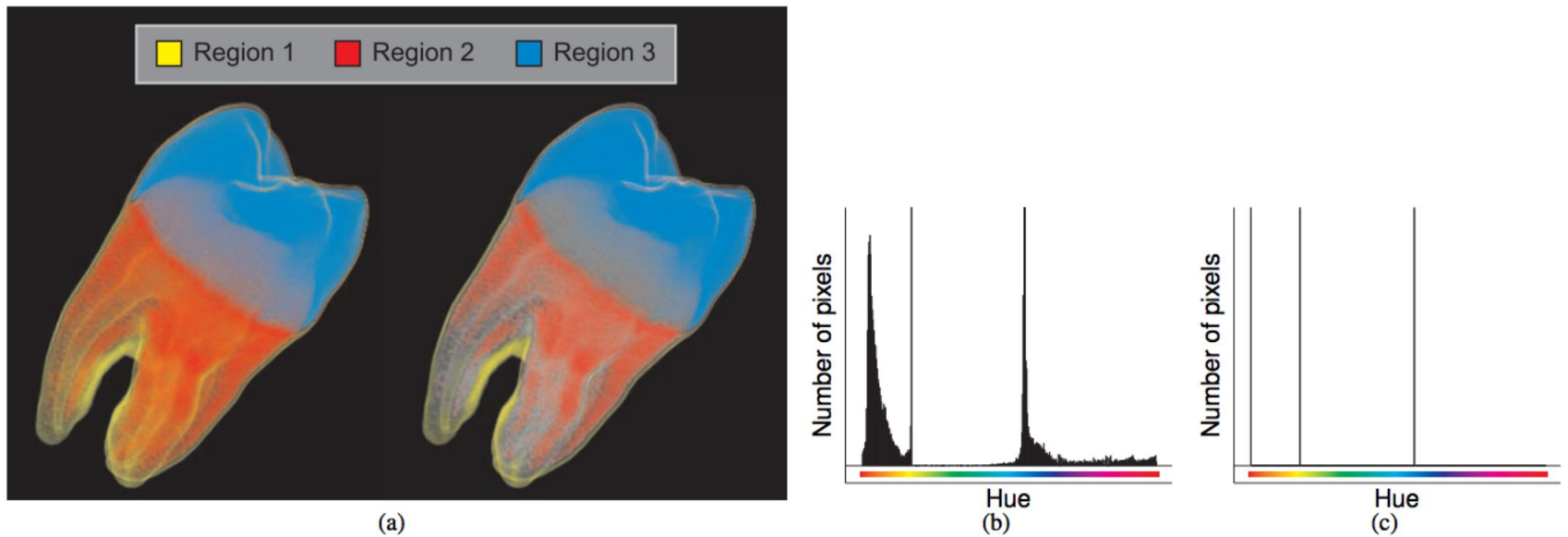
Fig. 7. (a) Traditional (left) and hue-preserving (right) rendering of a tooth data set. In the traditional rendering, orange colors can be seen where red and yellow mix. There are also purple hues where red and blue mix. These extraneous hues completely disappear in the hue-preserving rendering. The color hue histograms for both renderings are shown in (b) and (c). Note the three vertical lines in the hue-preserving histogram, representing the original color hues.

- Is this too lossy? Are we highlighting the important data or just showing the easy to present data?
- Needs a user study, with real case studies, and domain experts, measuring accuracy in domain-specific analysis

"Modeling Color Difference for Visualization Design"
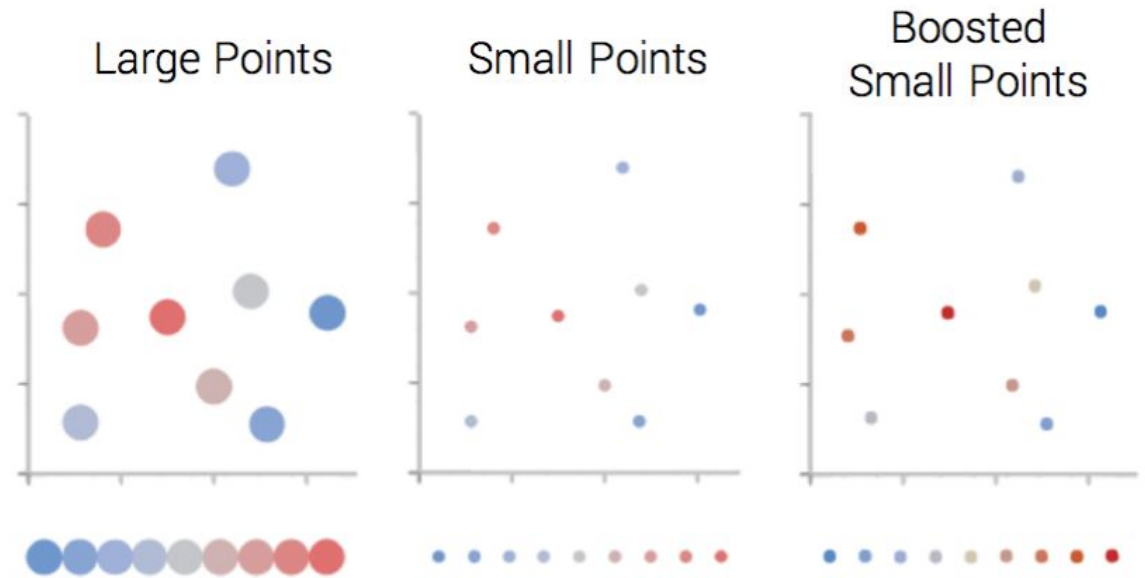Szafir, IEEE TVCG / IEEE VIS 2017

Large Points   Small Points   Boosted Small Points

Table 1. Regression results for points, where $p = m_x * \Delta X$.

Axis	Size (s)	Size in Px	Slope	R^2	$ND(50\%)$ in ΔE
L	0.25°	6 px	0.059	0.948	8.37
L	0.5°	12 px	0.074	0.97	6.74
L	0.75°	18px	0.087	0.981	5.75
L	1°	25px	0.087	0.965	5.75
L	1.5°	37 px	0.082	0.996	6.08
L	2°	50 px	0.091	0.974	5.47
a	0.25°	6 px	0.031	0.984	16.11
a	0.5°	12 px	0.05	0.988	9.98
a	0.75°	18px	0.059	0.987	8.52
a	1°	25px	0.064	0.992	7.81
a	1.5°	37 px	0.073	0.985	6.87
a	2°	50 px	0.073	0.994	6.84
b	0.25°	6 px	0.026	0.978	19.46
b	0.5°	12 px	0.037	0.988	13.34
b	0.75°	18px	0.044	0.994	11.35
b	1°	25px	0.05	0.979	10.03
b	1.5°	37 px	0.056	0.979	8.97
b	2°	50 px	0.063	0.99	7.99

Table 2. Regression results for lines, where $p = m_x * \Delta X$.

Axis	Size (s)	Size in Pixels	Slope (m)	R^2	$ND(50\%)$ in ΔE
L	0.05°	2px	0.033	0.876	15.35
L	0.1°	3px	0.042	0.92	11.98
L	0.15°	4px	0.058	0.921	8.69
L	0.25°	6px	0.065	0.955	7.74
L	0.3°	7px	0.069	0.947	7.23
L	0.35°	9px	0.072	0.96	6.92
a	0.05°	2px	0.036	0.978	13.92
a	0.1°	3px	0.043	0.956	11.57
a	0.15°	4px	0.049	0.959	10.28
a	0.25°	6px	0.053	0.94	9.39
a	0.3°	7px	0.061	0.933	8.15
a	0.35°	9px	0.064	0.919	7.79
b	0.05°	2px	0.026	0.981	19.47
b	0.1°	3px	0.031	0.967	16.15
b	0.15°	4px	0.033	0.934	15.17
b	0.25°	6px	0.036	0.918	13.75
b	0.3°	7px	0.04	0.927	12.43
b	0.35°	9px	0.045	0.945	11.05