cs6964 | January 23 2012

VISUAL ENCODING

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slide acknowledgements:

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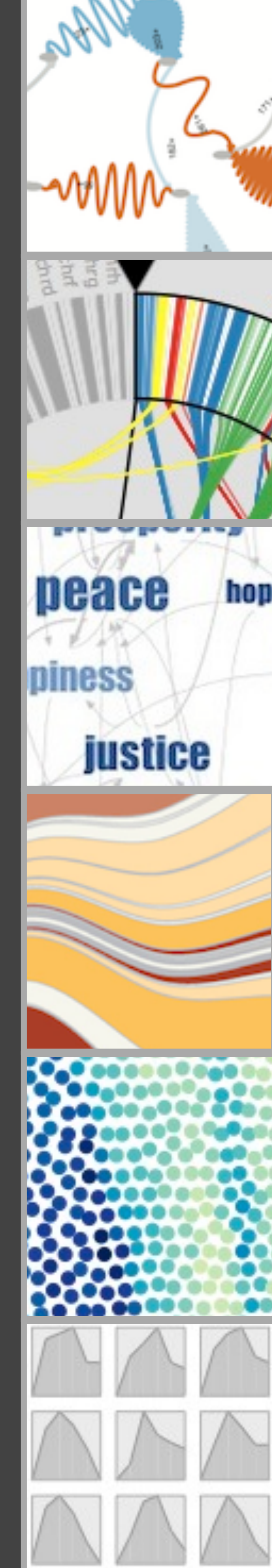
Bang Wong, Broad Institute



LAST TIME

DATASET TYPES

tables

networks

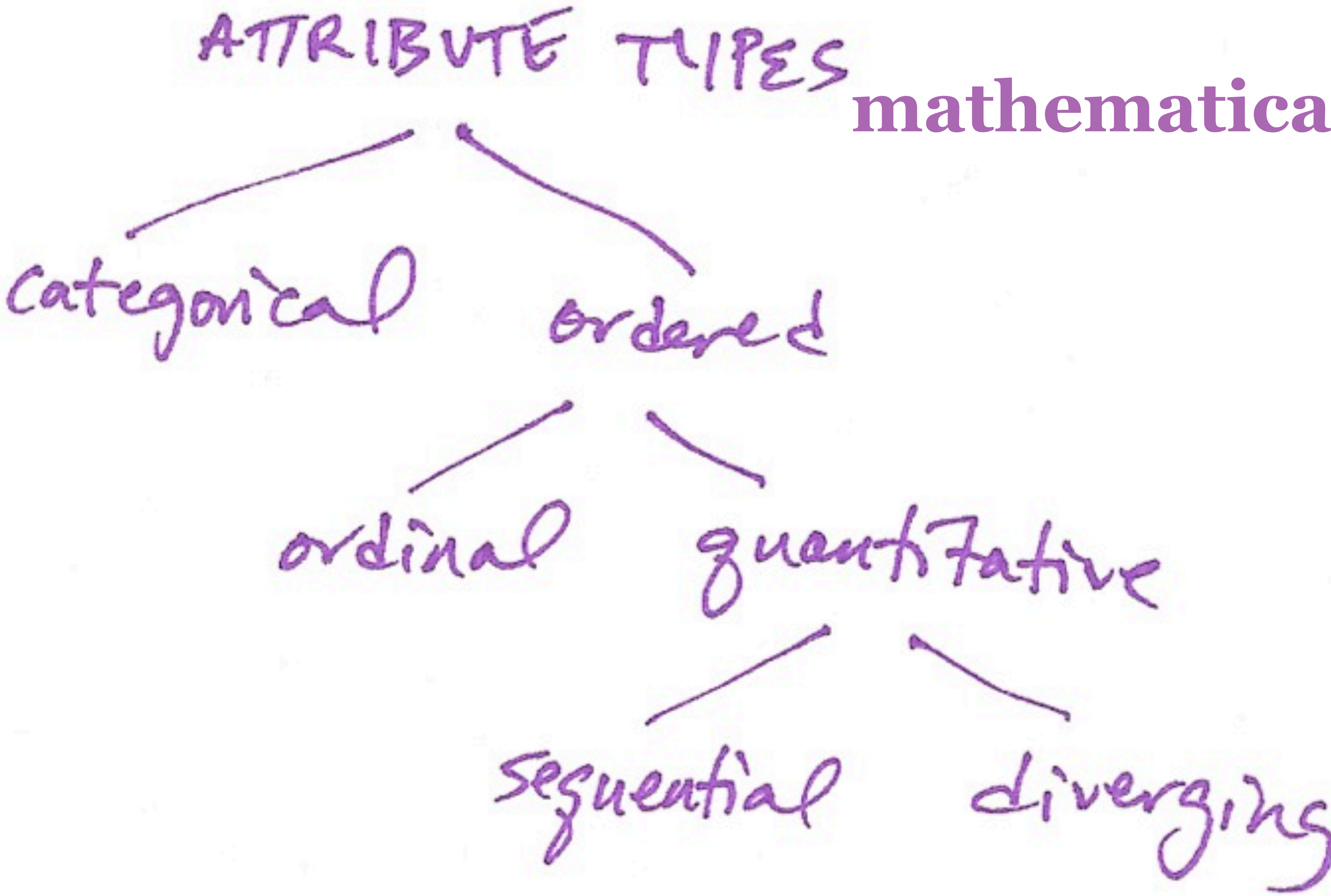
text/logs

A	B	C	S	T	U
Order ID	Order Date	Order Priority	Product Container	Product Base Margin	Ship Date
3	10/14/06	5-Low	Large Box	0.8	10/21/06
6	2/21/08	4-Not Specified	Small Pack	0.55	2/22/08
32	7/16/07	2-High	Small Pack	0.79	7/17/07
32	7/16/07	2-High	Jumbo Box	[illegible]	7/17/07
32	7/16/07	2-High	Medium Box	[illegible]	7/18/07
32	7/16/07	2-High	Medium Box	[illegible]	7/18/07
35	10/23/07	4-Not Specified	Wrap Bag	0.52	10/24/07
35	10/23/07	4-Not Specified	Small Box	0.58	10/25/07
[illegible]	1/3/07	1-Urgent	Small Box	0.55	11/3/07
[illegible]	/18/07	1-Urgent	Small Pack	0.49	3/19/07
66	1/20/05	5-Low	Wrap Bag	0.56	1/20/05
69	6/4/05	4-Not Specified	Small Pack	0.44	6/6/05
69	6/4/05	4-Not Specified	Wrap Bag	0.6	6/6/05
70	12/18/06	5-Low	Small Box	0.59	12/23/06
70	12/18/06	5-Low	Wrap Bag	0.82	12/23/06
96	4/17/05	2-High	Small Box	0.55	4/19/05
97	1/29/06	3-Medium	Small Box	0.38	1/30/06
129	11/19/08	5-Low	Small Box	0.37	11/28/08
130	5/8/08	2-High	Small Box	0.37	5/9/08
130	5/8/08	2-High	Medium Box	0.38	5/10/08
130	5/8/08	2-High	Small Box	0.6	5/11/08
132	6/11/06	3-Medium	Medium Box	0.6	6/12/06
132	6/11/06	3-Medium	Jumbo Box	0.69	6/14/06
134	5/1/08	4-Not Specified	Large Box	0.82	5/3/08
135	10/21/07	4-Not Specified	Small Pack	0.64	10/23/07
166	9/12/07	2-High	Small Box	0.55	9/14/07
193	8/8/06	1-Urgent	Medium Box	0.57	8/10/06
194	4/5/08	3-Medium	Wrap Bag	0.42	4/7/08

attribute

item

mathematical interpretation



ATTRIBUTE SEMANTICS

DATASET SEMANTICS

real-world meaning
visualization specific

DATA vs CONCEPTUAL MODEL

- **from data model . . .**
  - 32.52, 54.06, -17.35, . . . (floats)
- **using conceptual model . . .**
  - temperature
- **to data type.**
  - continuous to 2 significant figures (Q)
  - hot, warm , cold (O)
  - above freezing, below freezing (C)

- **relativity of perception**
- **marks and channels**
- **planar position**
- **color**

target

↓

translate

↓

design

↓

implement

↓

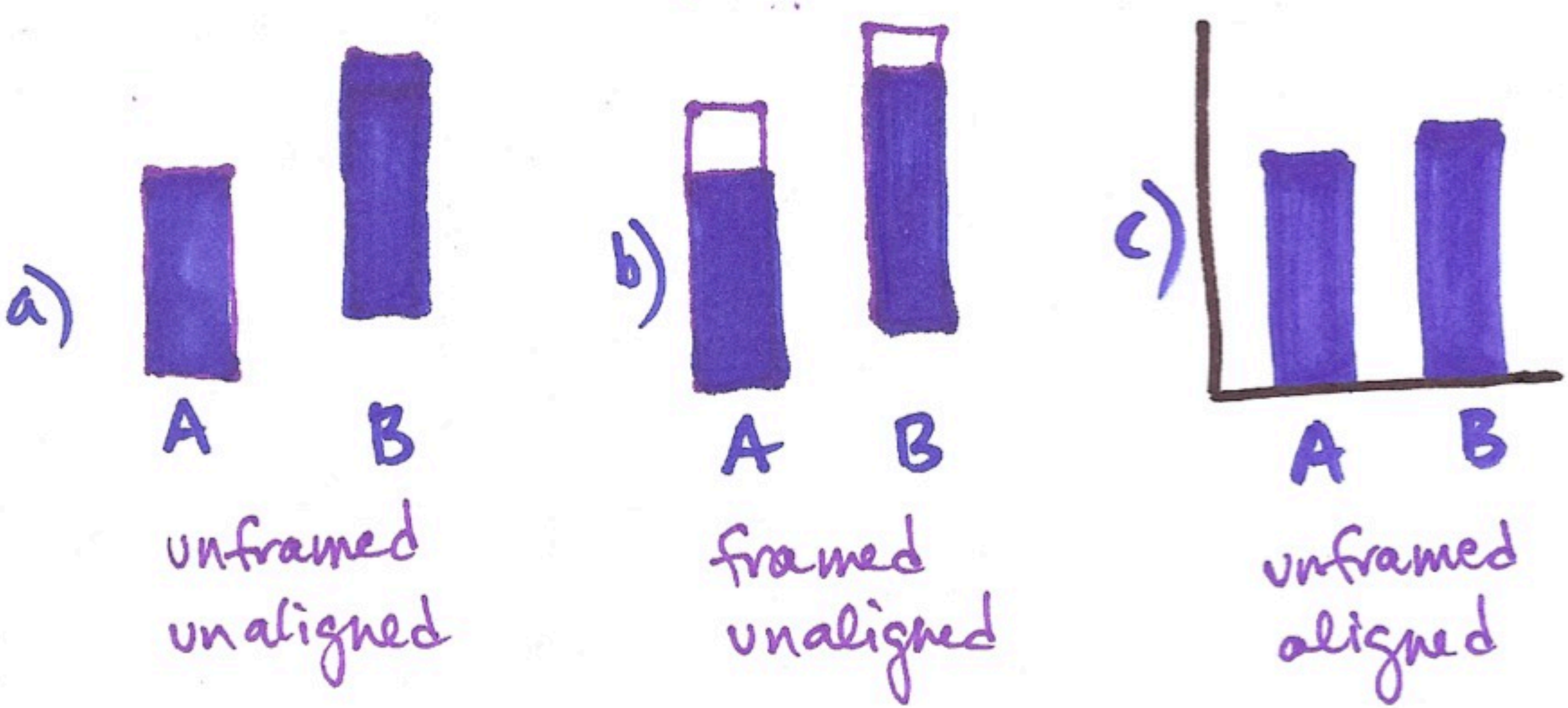
validate

comments on readings?

- **relativity of perception**
- **marks and channels**
- **planar position**
- **color**

WEBER'S LAW

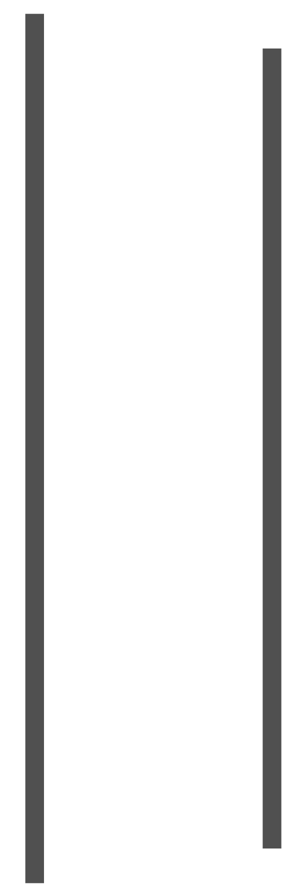
we judge based on relative, not absolute, differences



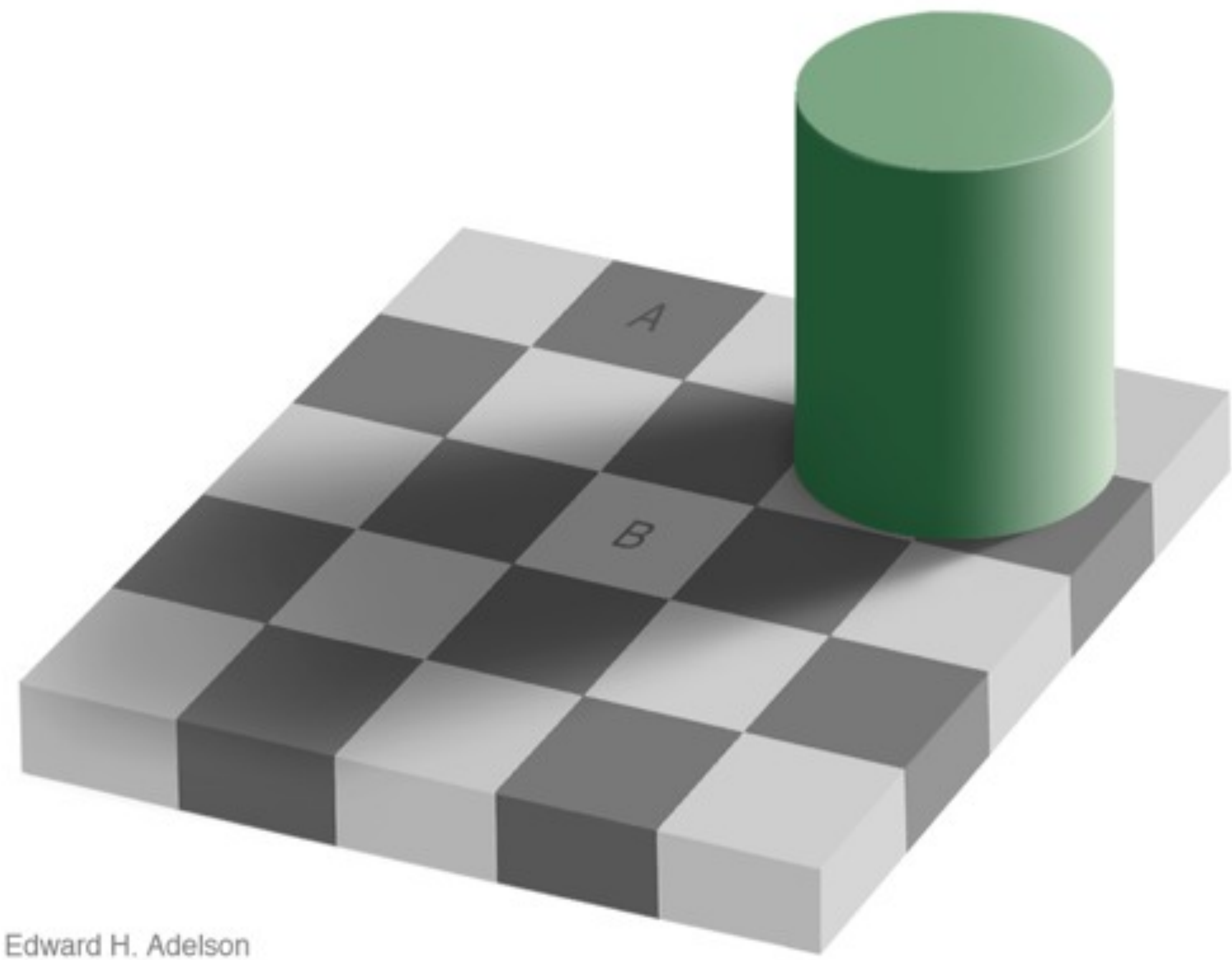
RELATIVE DIFFERENCES

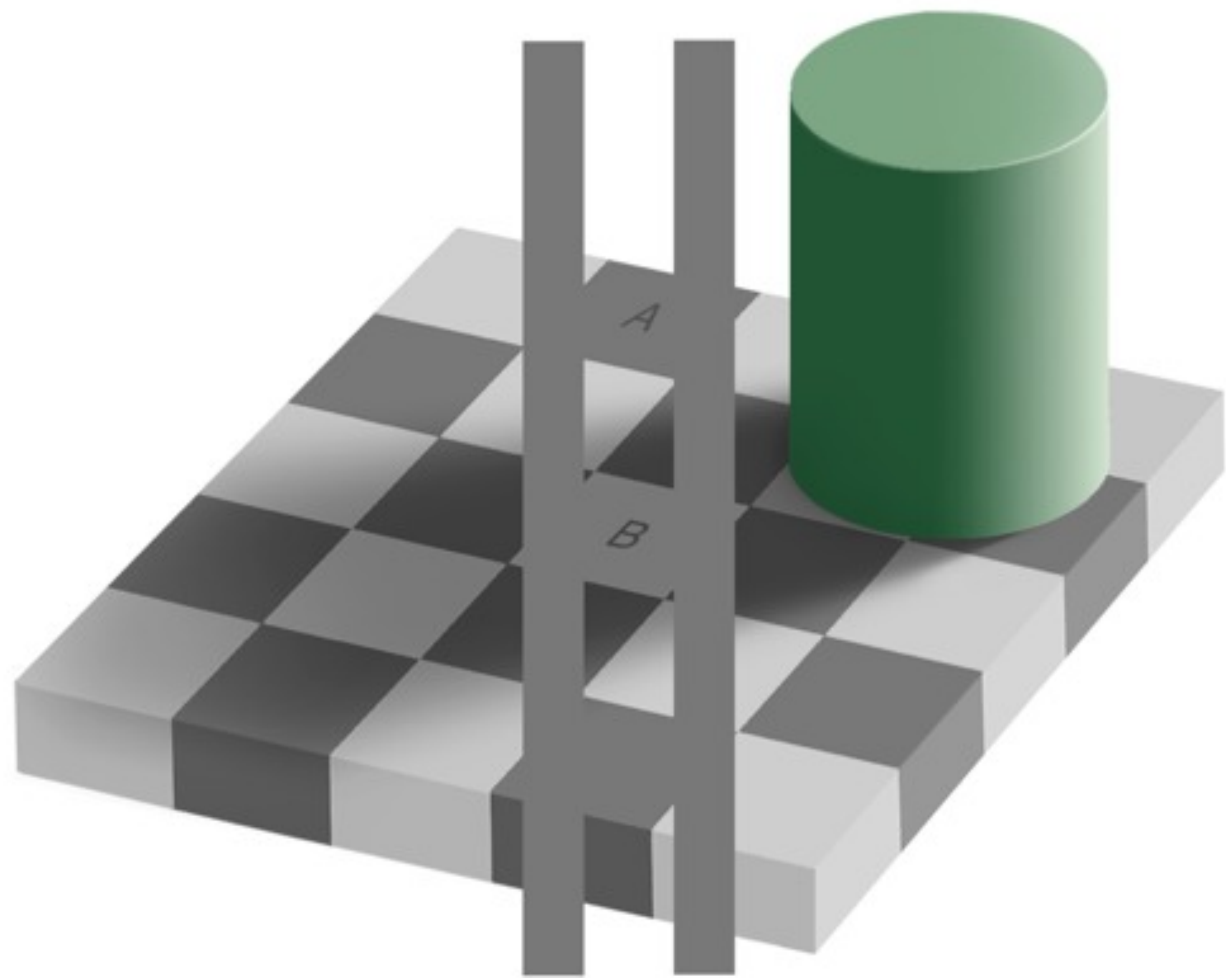
AXIS OF ALIGNMENT

AXIS OF ALIGNMENT



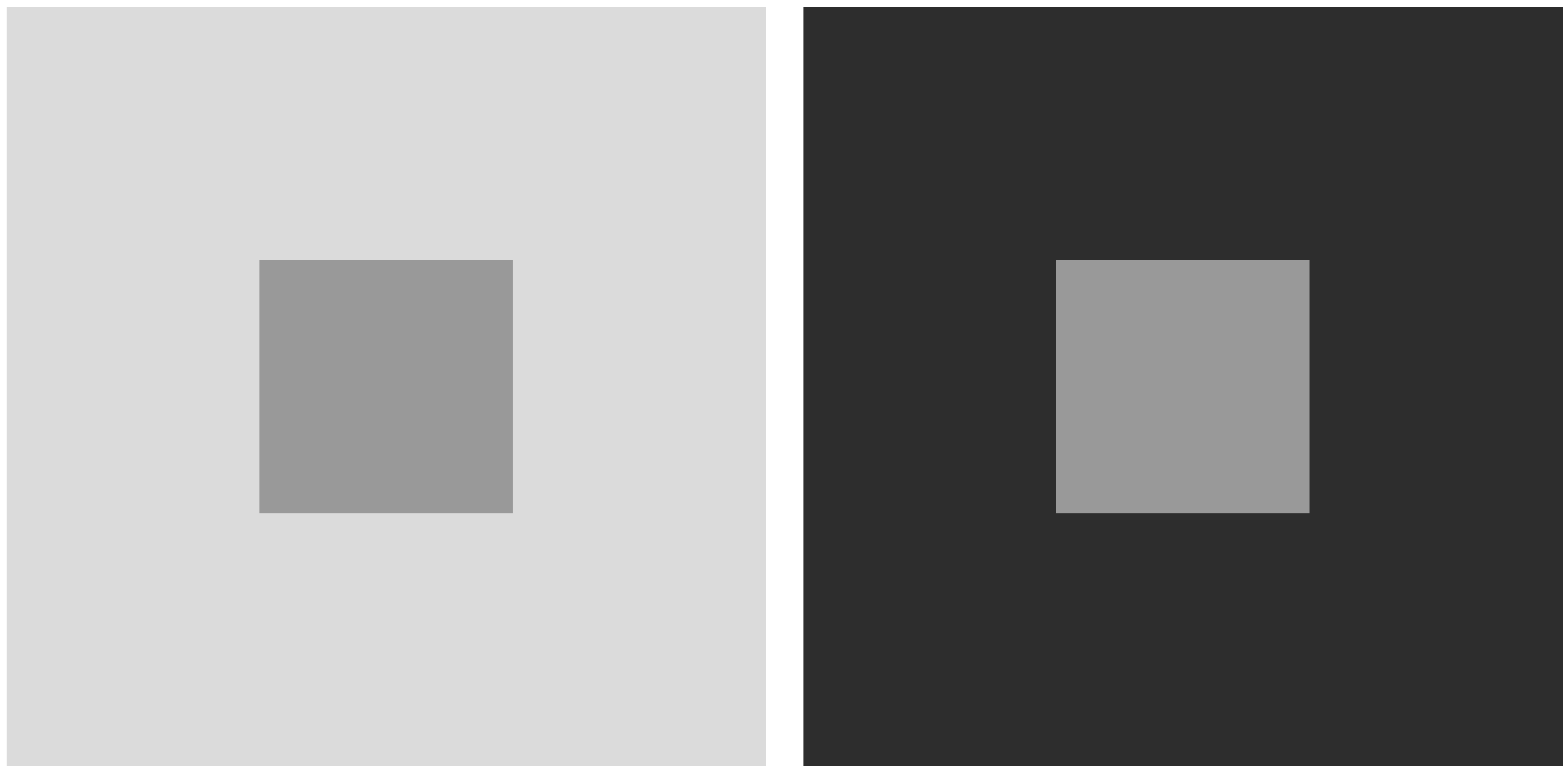
SIMULTANEOUS CONTRAST



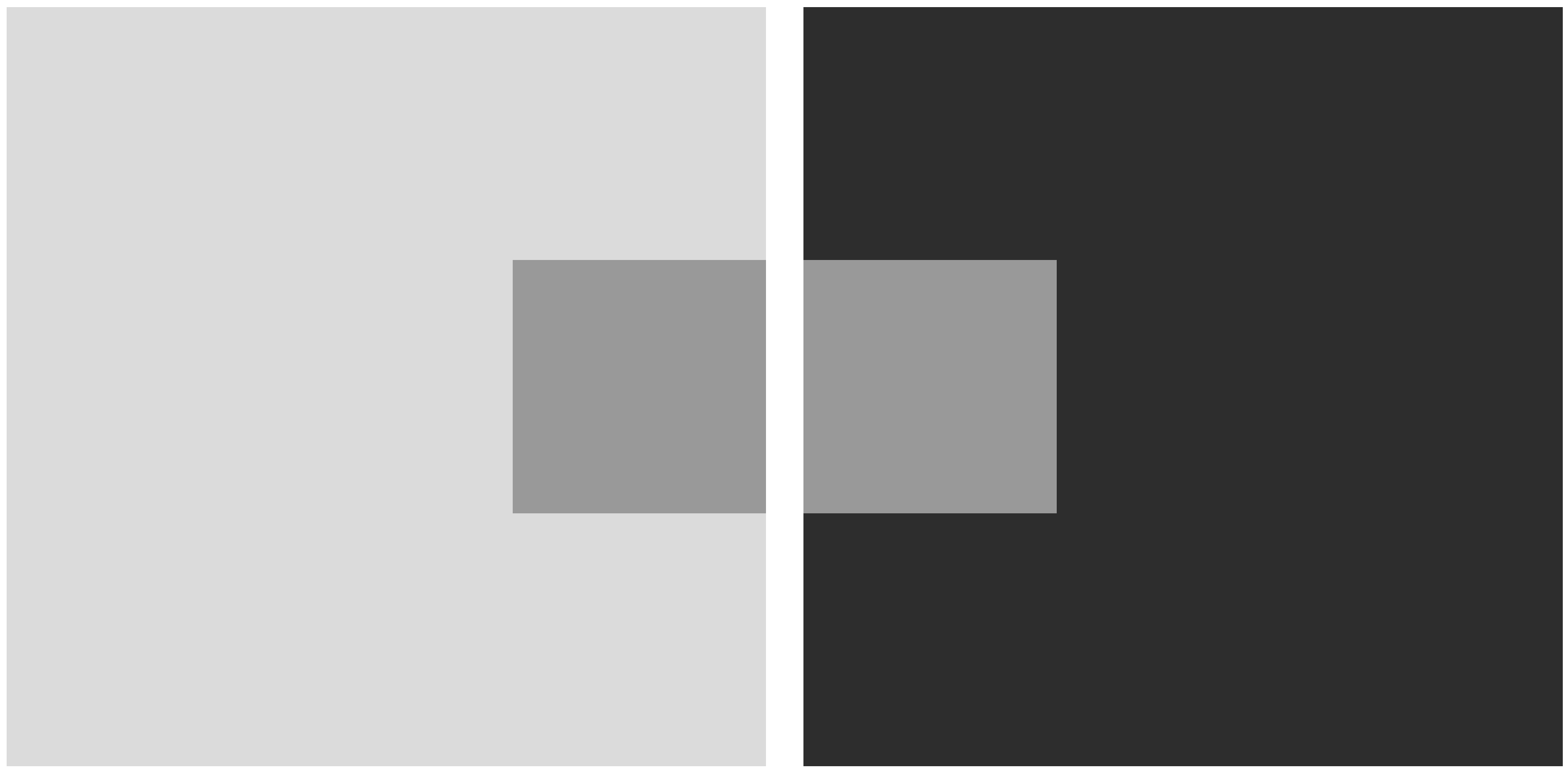


http://persci.mit.edu/_media/gallery/checkershadow_double_full.jpg

SIMULTANEOUS CONTRAST

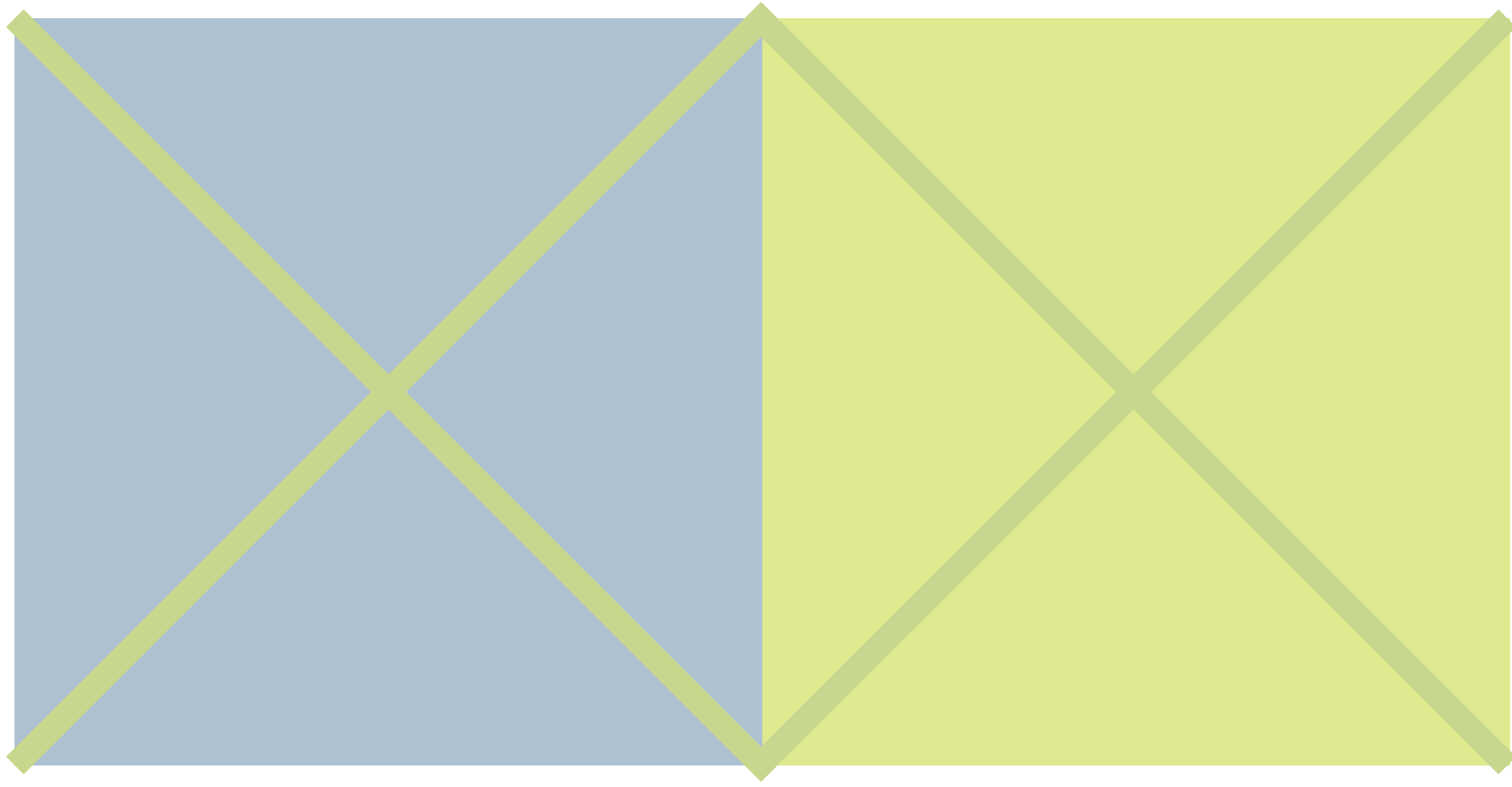


SIMULTANEOUS CONTRAST

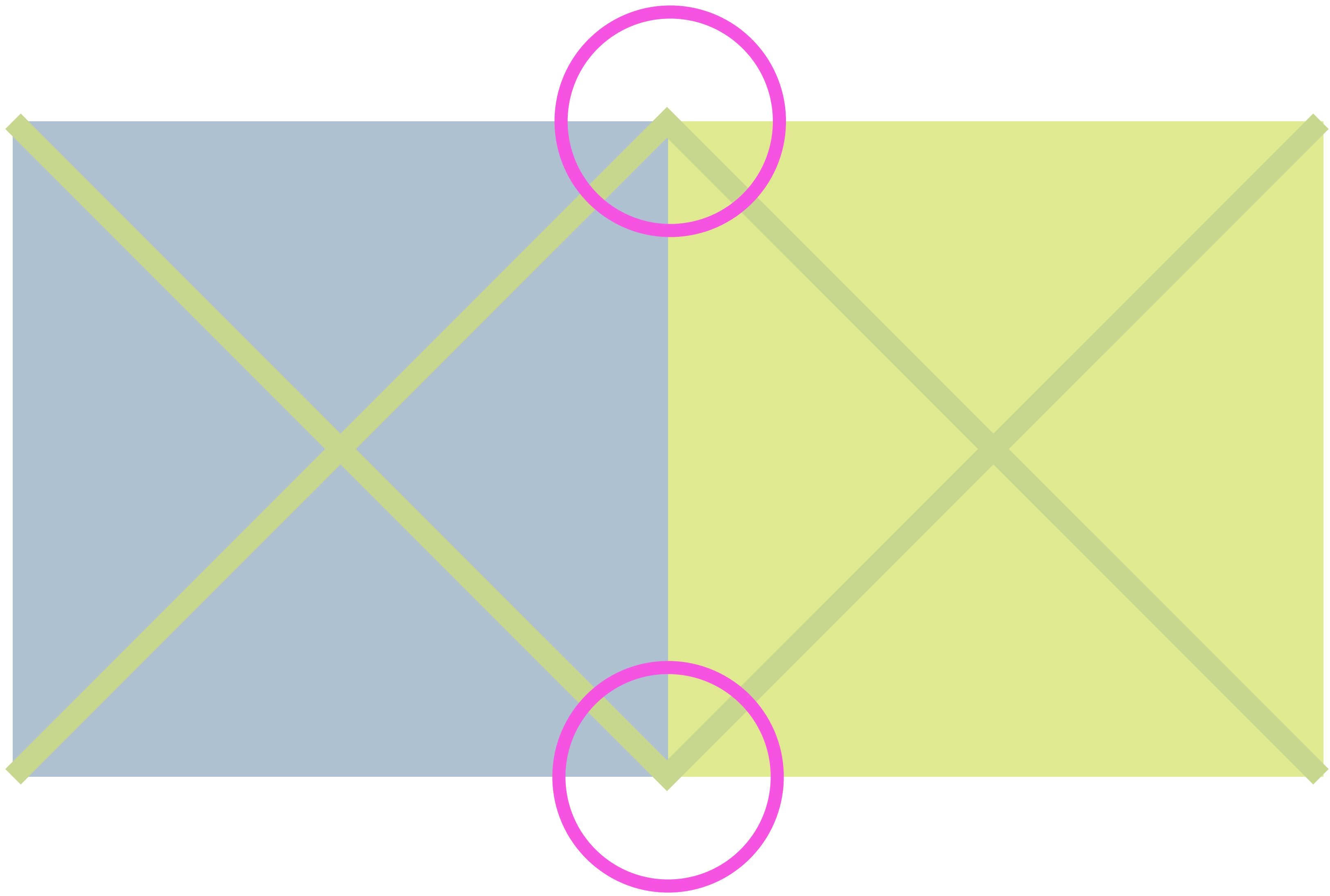


SIMULTANEOUS CONTRAST

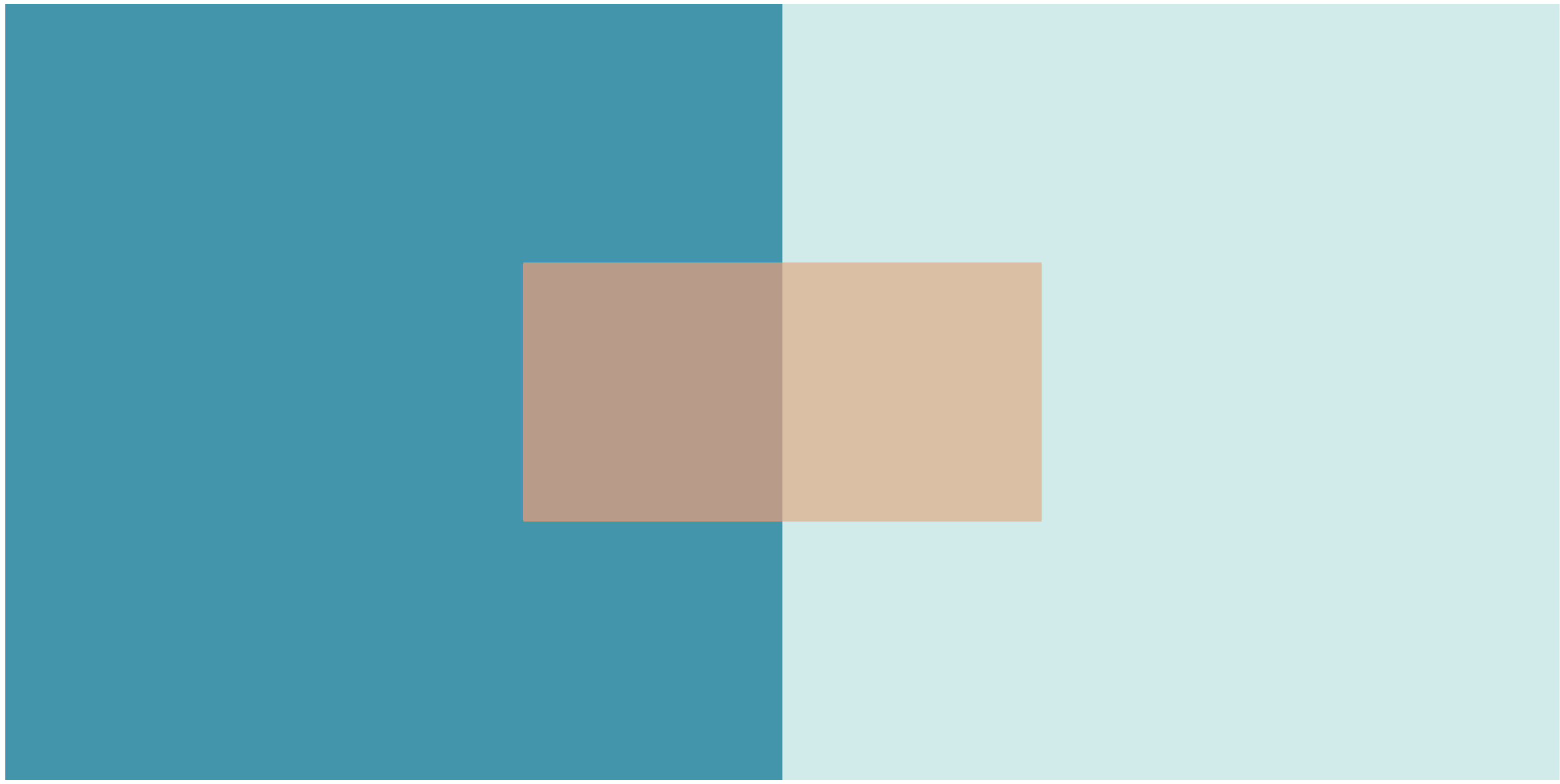
INTERACTION OF COLOR



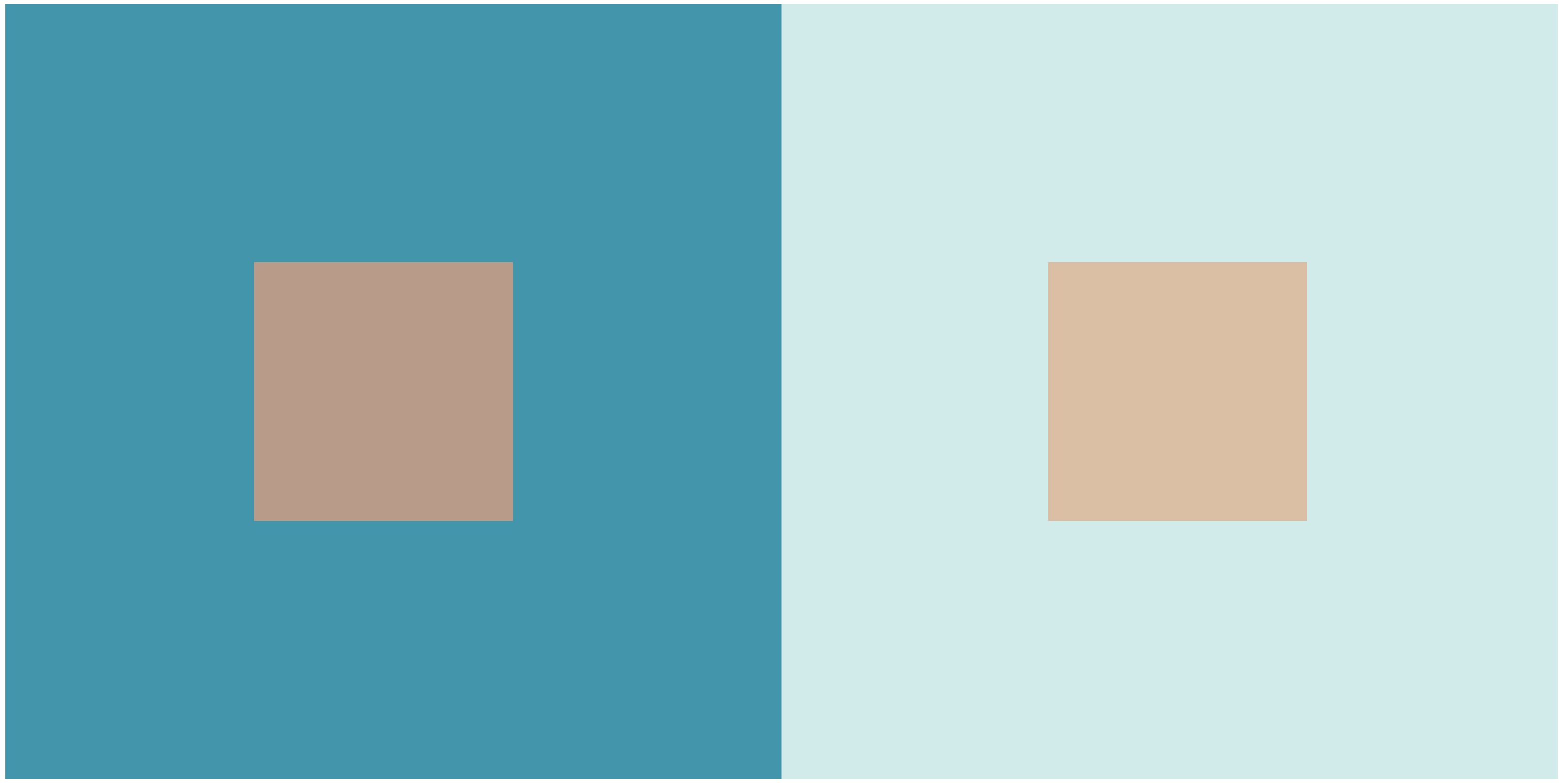
INTERACTION OF COLOR



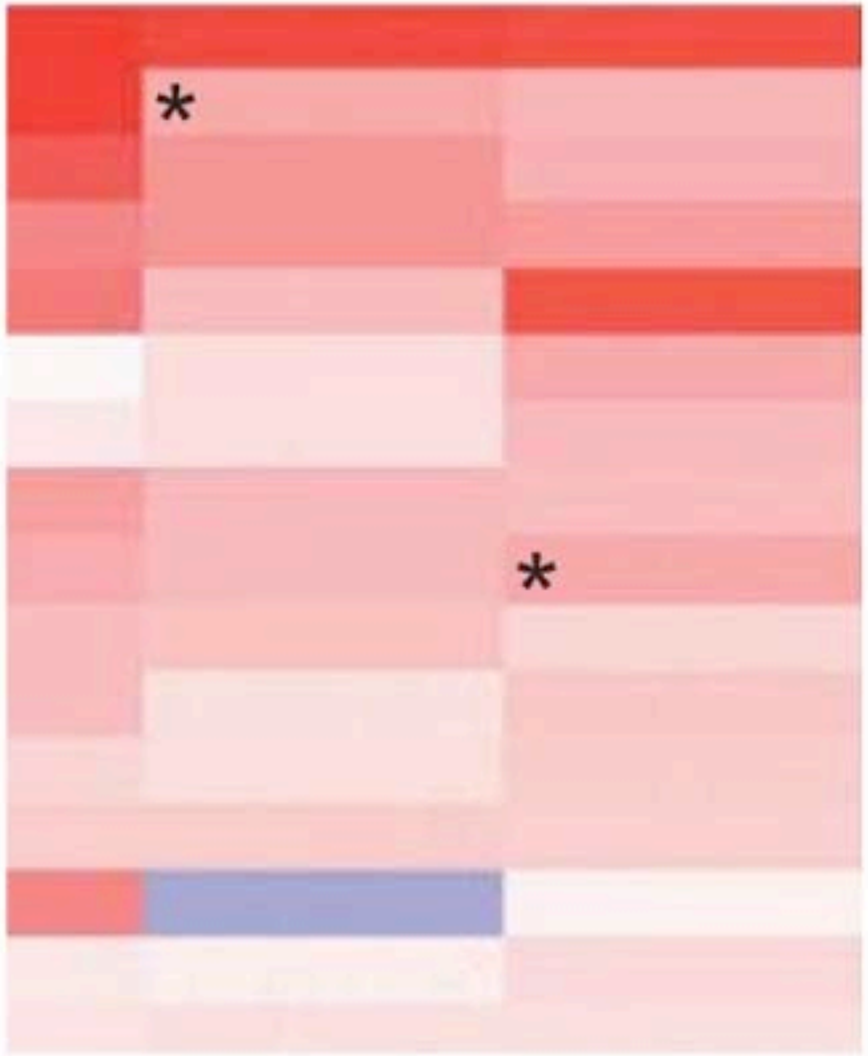
INTERACTION OF COLOR



INTERACTION OF COLOR



INTERACTION OF COLOR



Wong 2010

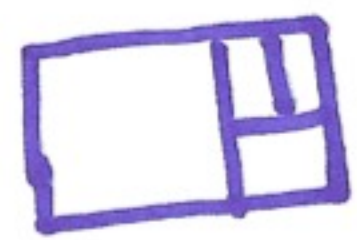
- relativity of perception
- **marks and channels**
- planar position
- color

MARKS
geometric primitives

0D points

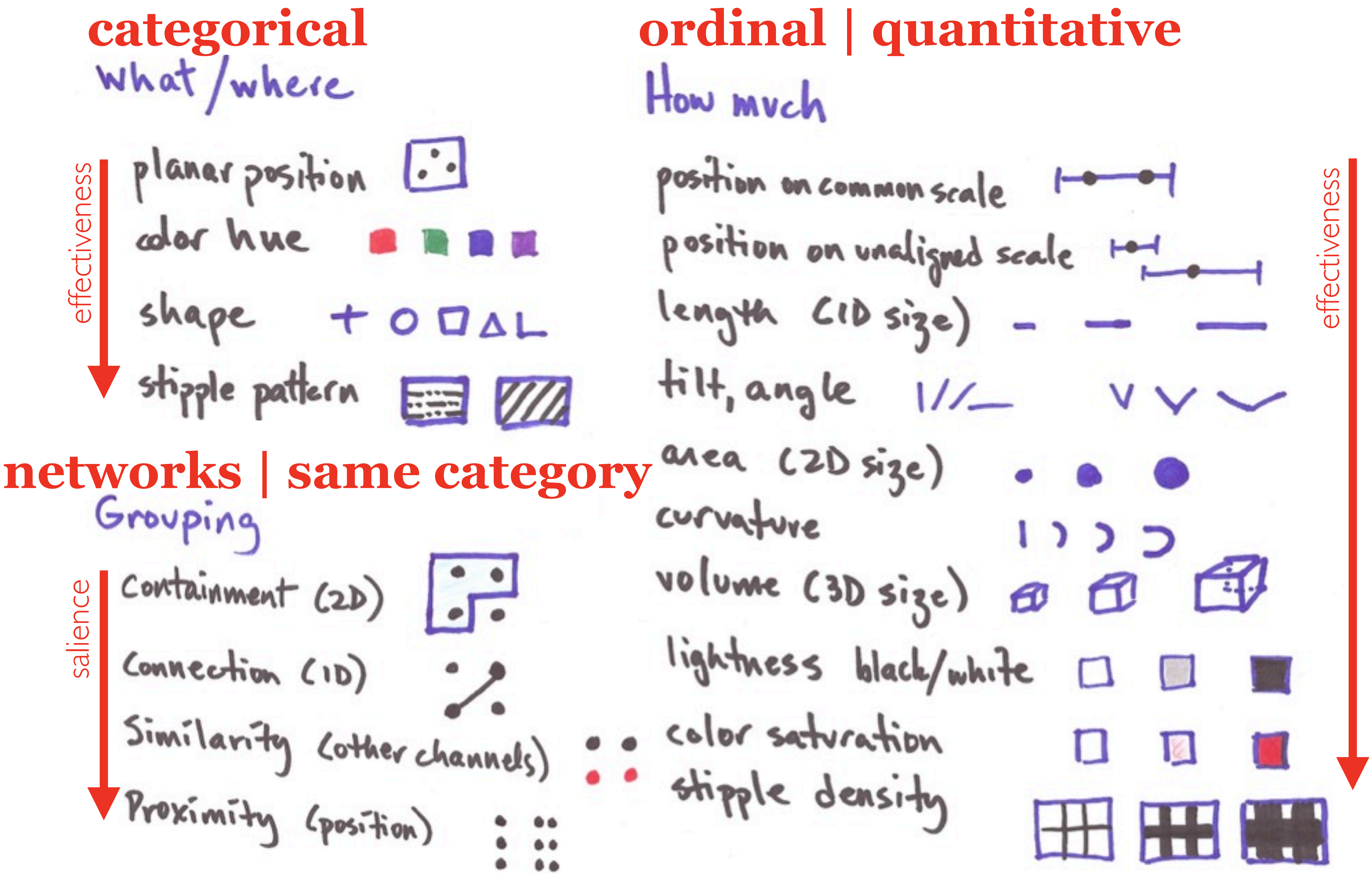
1D lines

2D areas



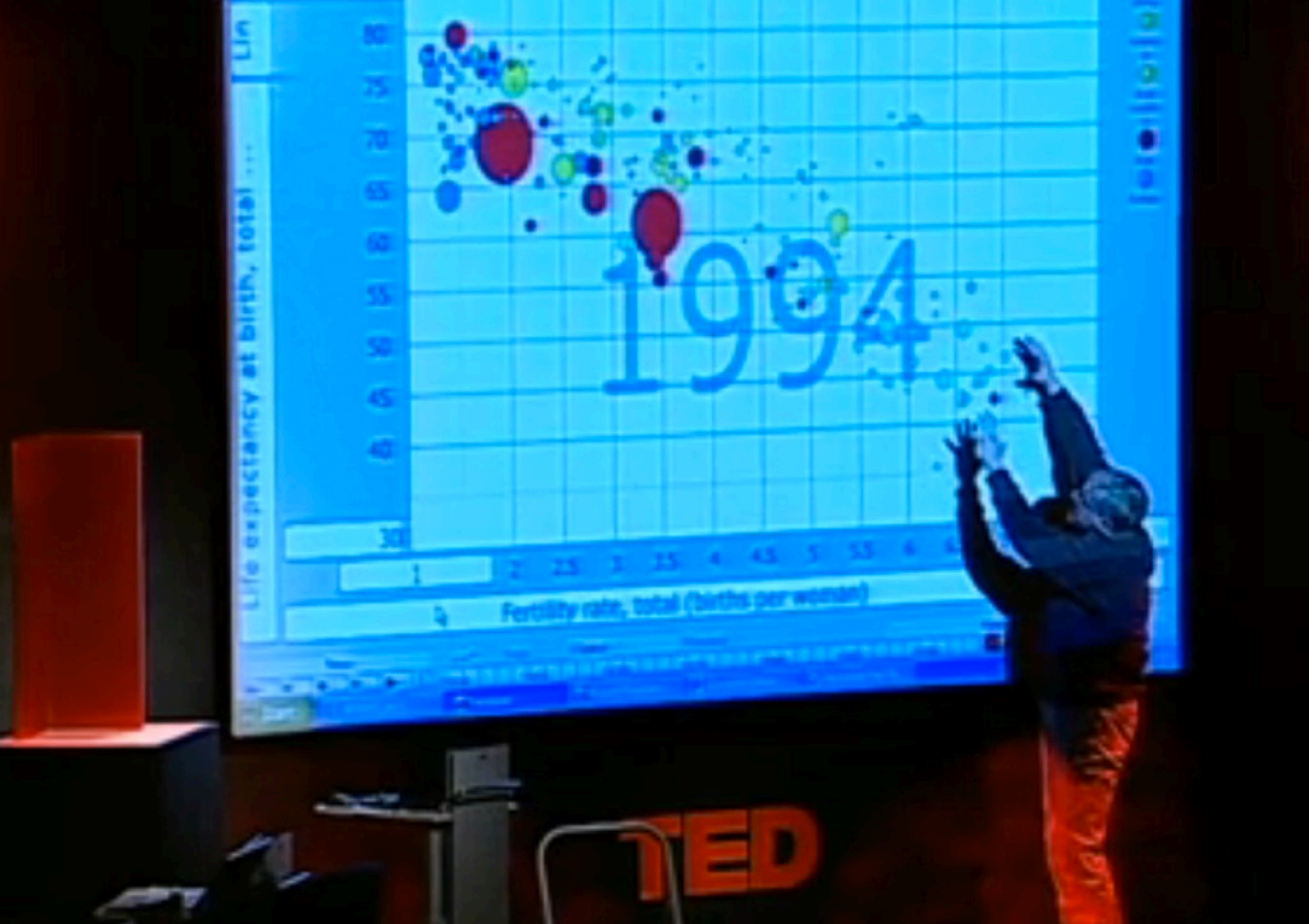
CHANNELS

parameters that control the appearance of marks

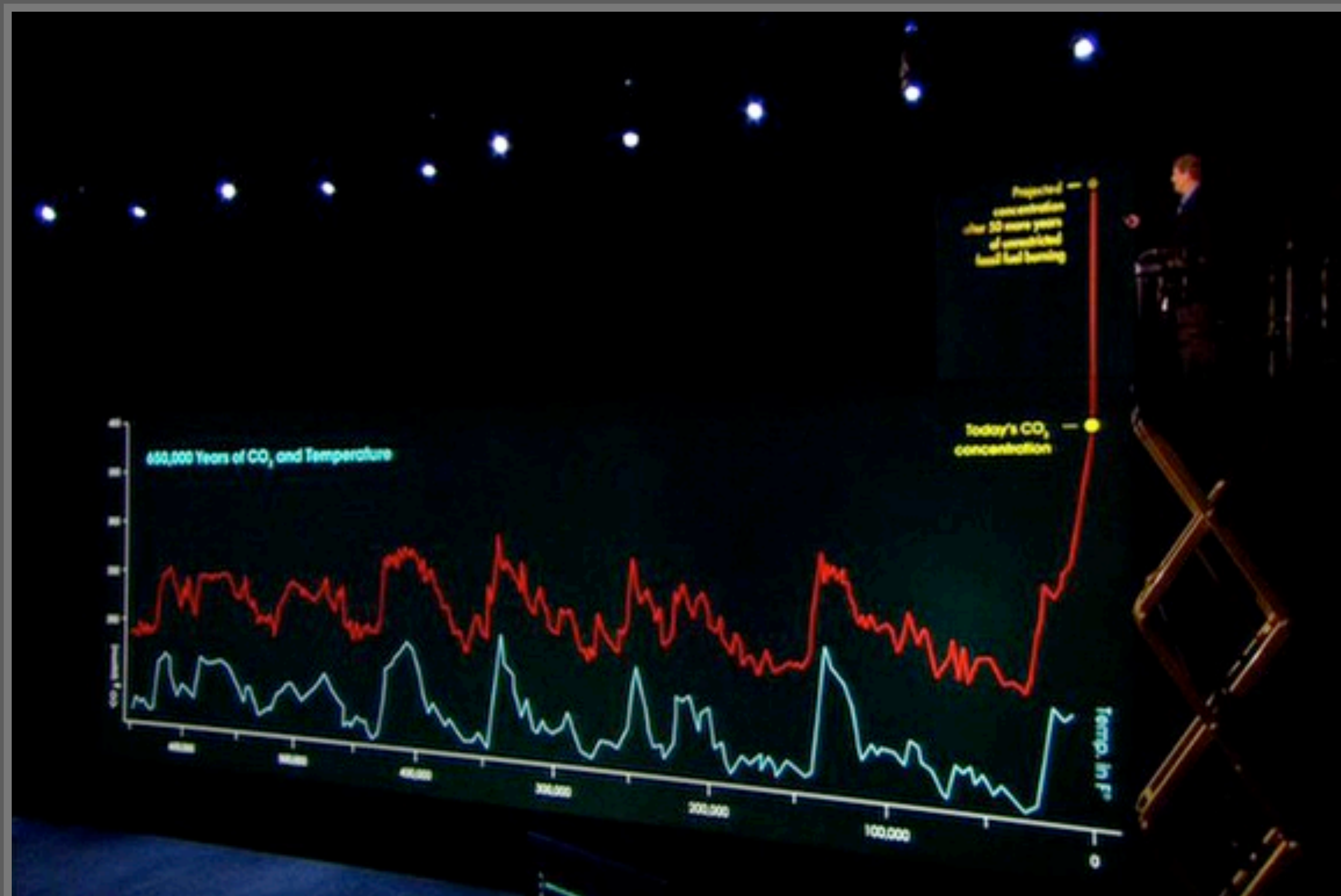


categorical
what/where
effectiveness
planar position
color hue
shape
stipple pattern
networks | same category
Grouping
salience
Containment (2D)
Connection (1D)
Similarity (other channels)
Proximity (position)
ordinal | quantitative
How much
effectiveness
position on common scale
position on unaligned scale
length (1D size)
tilt, angle
area (2D size)
curvature
volume (3D size)
lightness black/white
color saturation
stipple density

name that channel . . .



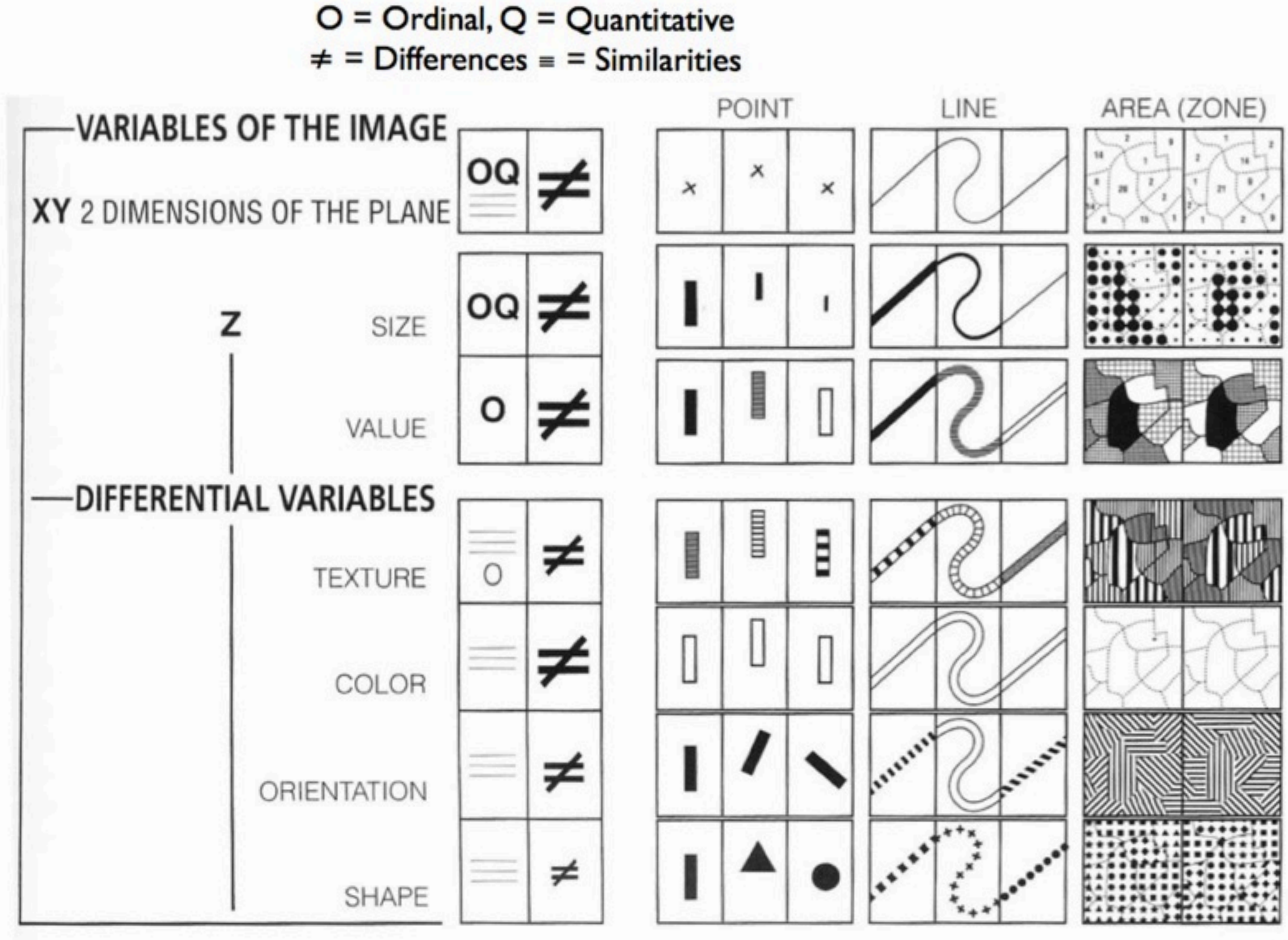
http://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen.html



http://www.good.is/post/how-might-we-visualize-data-in-more-effective-and-inspiring-ways/

WHERE DO RANKINGS COME FROM?

Bertin, 1967


O = Ordinal, Q = Quantitative
≠ = Differences ≡ = Similarities
POINT
LINE
AREA (ZONE)
VARIABLES OF THE IMAGE
XY 2 DIMENSIONS OF THE PLANE
OQ
≠
Z
SIZE
OQ
≠
VALUE
O
≠
DIFFERENTIAL VARIABLES
TEXTURE
O
≠
COLOR
≠
ORIENTATION
≠
SHAPE
≠

Cleveland & McGill, 1984

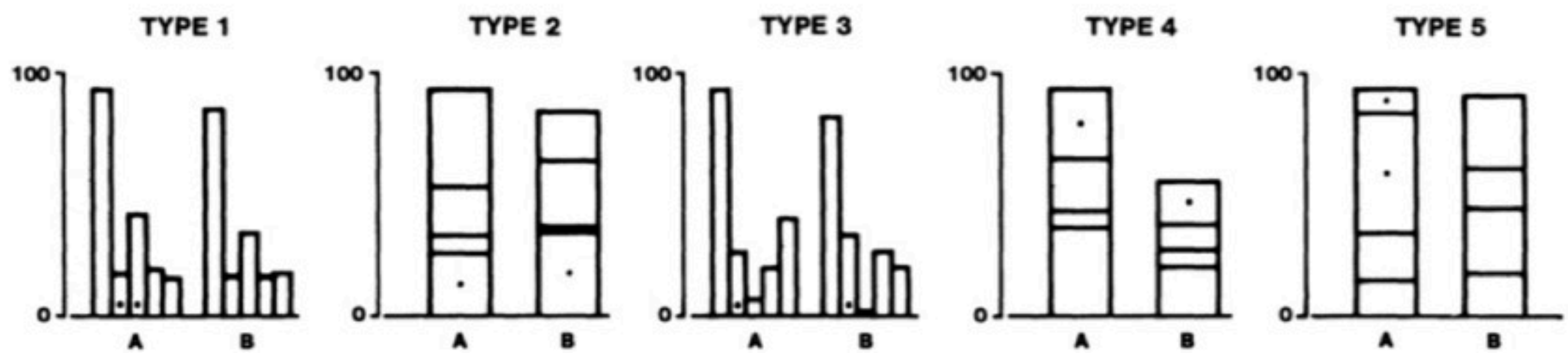


Figure 4. Graphs from position–length experiment.

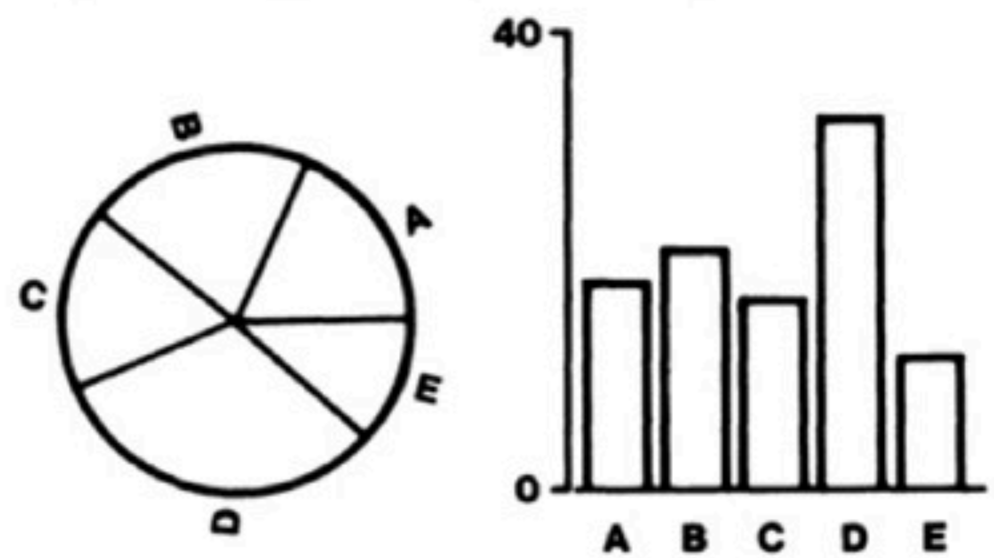


Figure 3. Graphs from position–angle experiment.

Heer & Bostock, 2010

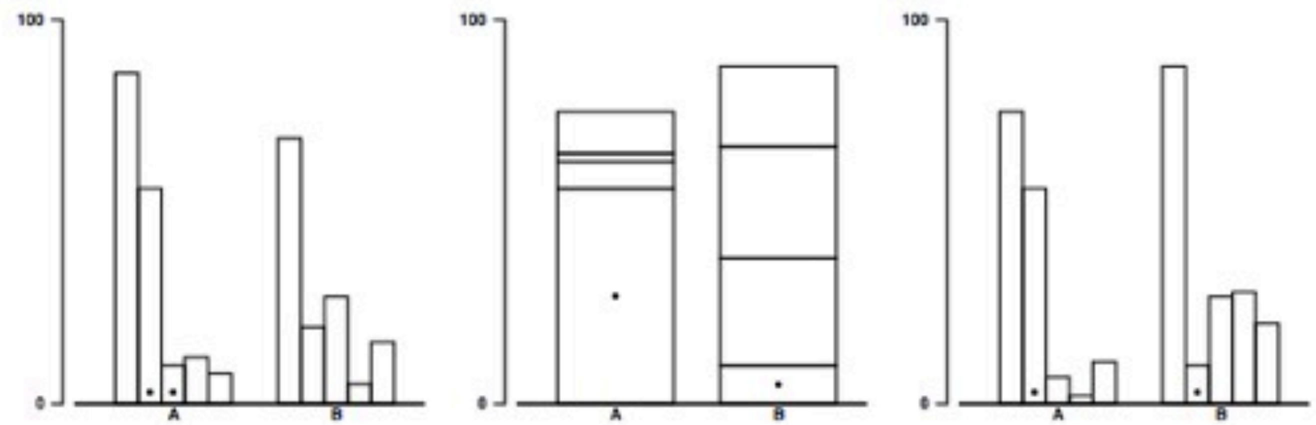


Figure 1: Stimuli for judgment tasks T1, T2 & T3. Subjects estimated percent differences between elements.

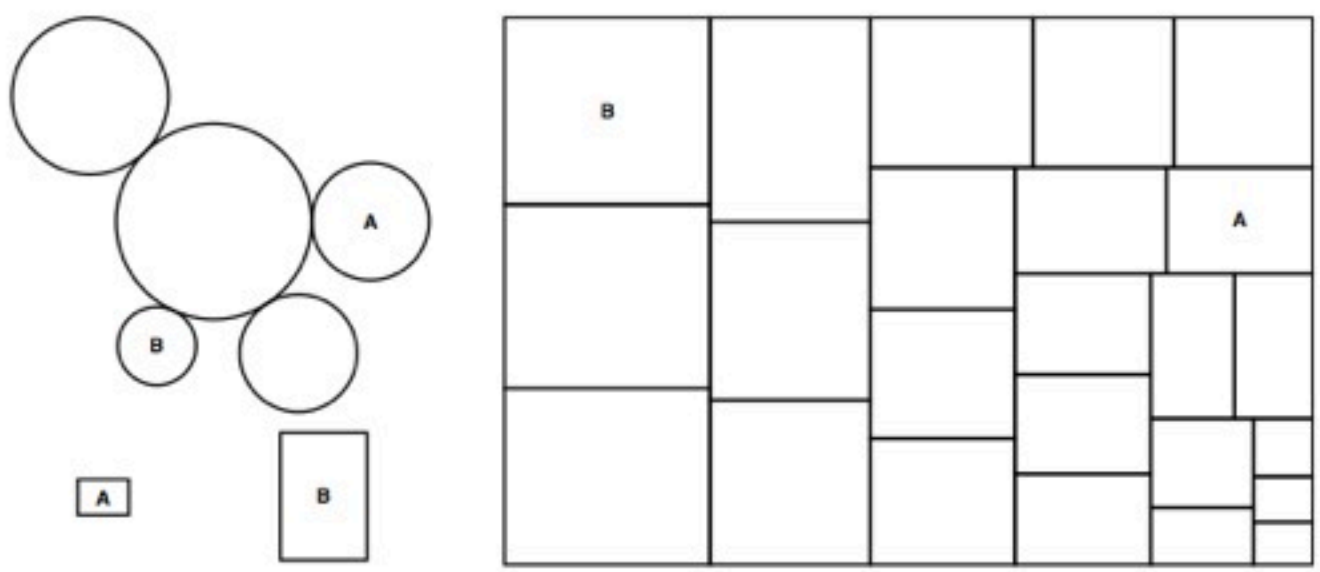
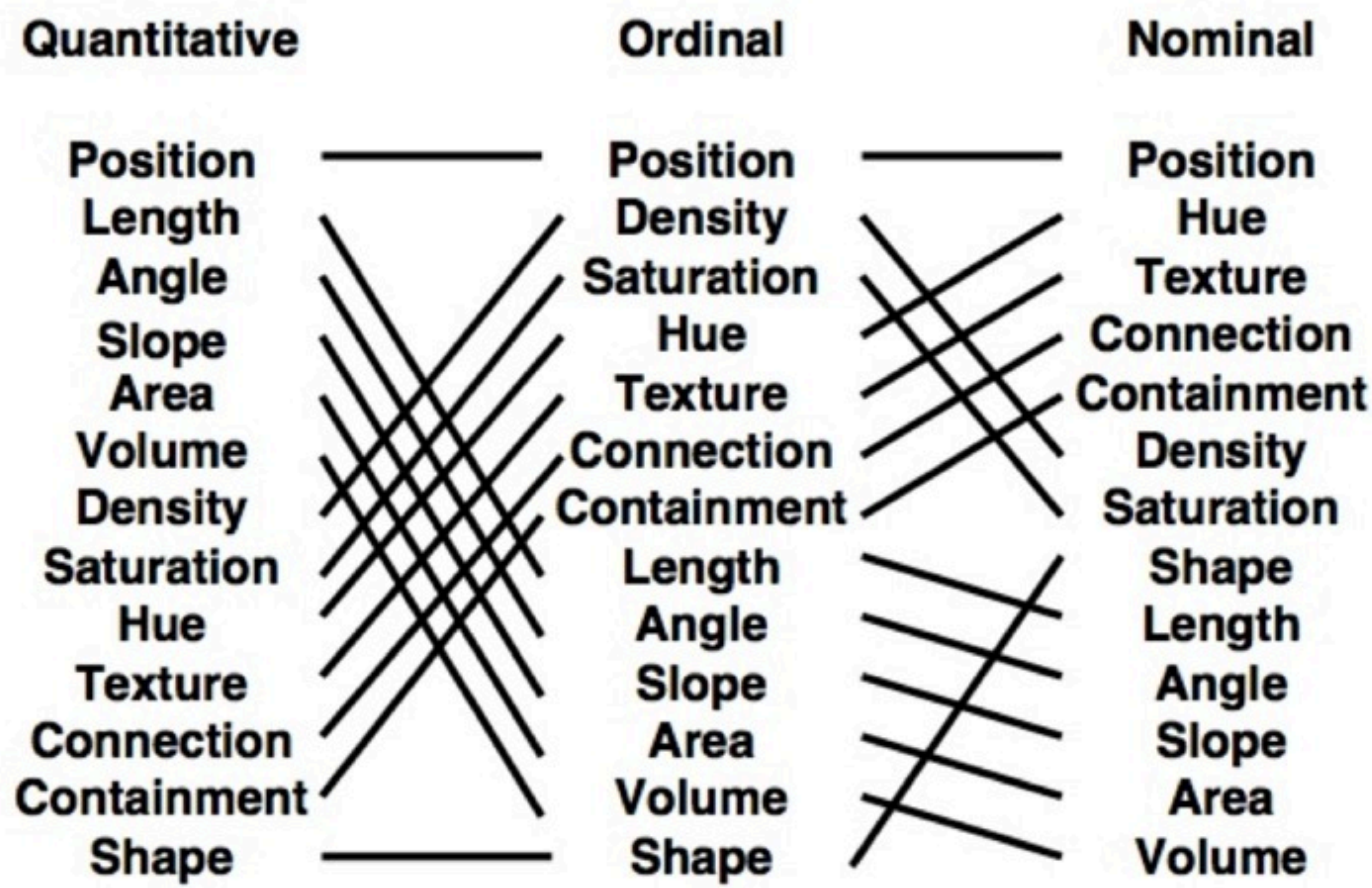
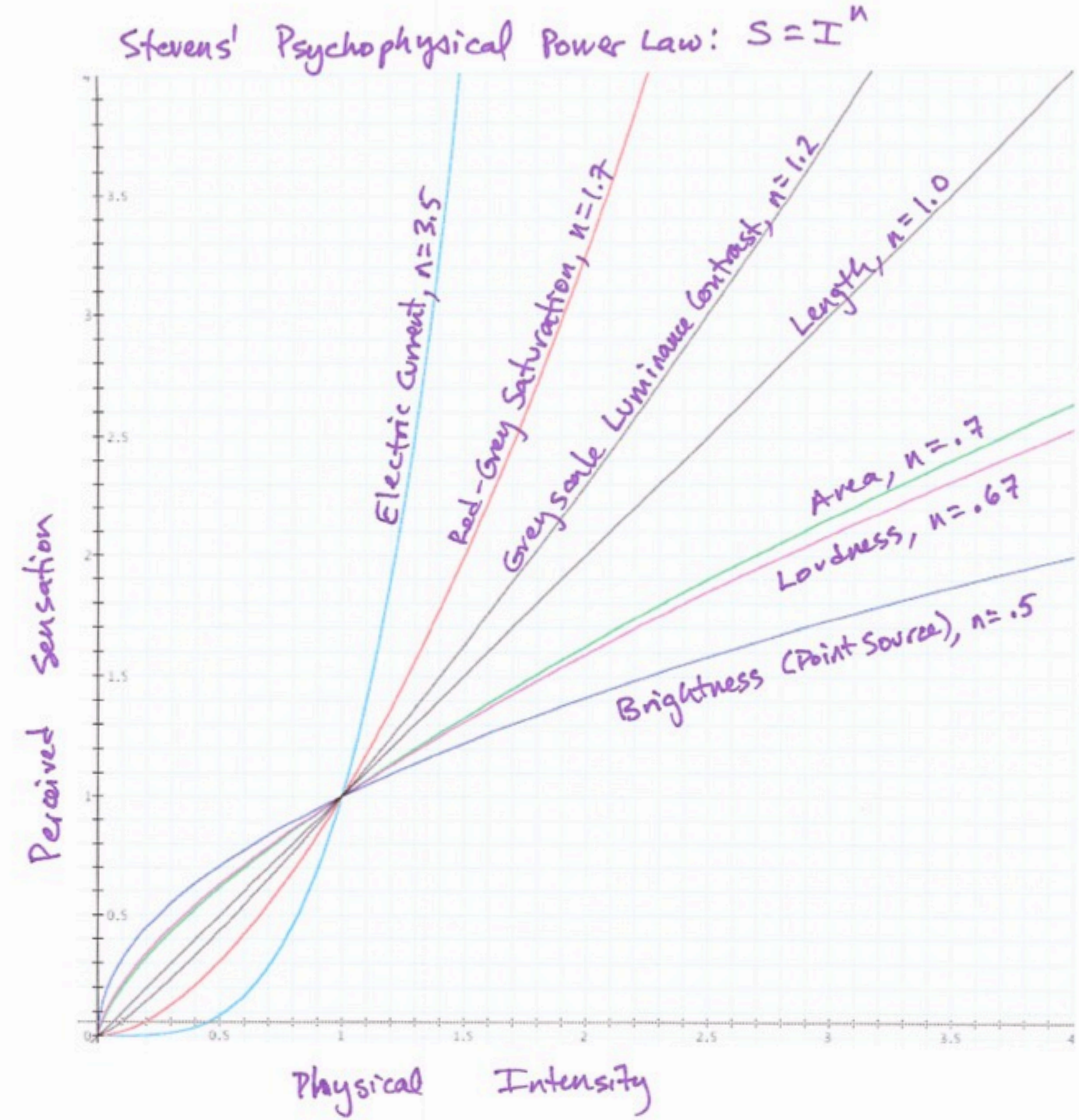


Figure 2: Area judgment stimuli. Top left: Bubble chart (T7), Bottom left: Center-aligned rectangles (T8), Right: Treemap (T9).

Mackinlay, 1986

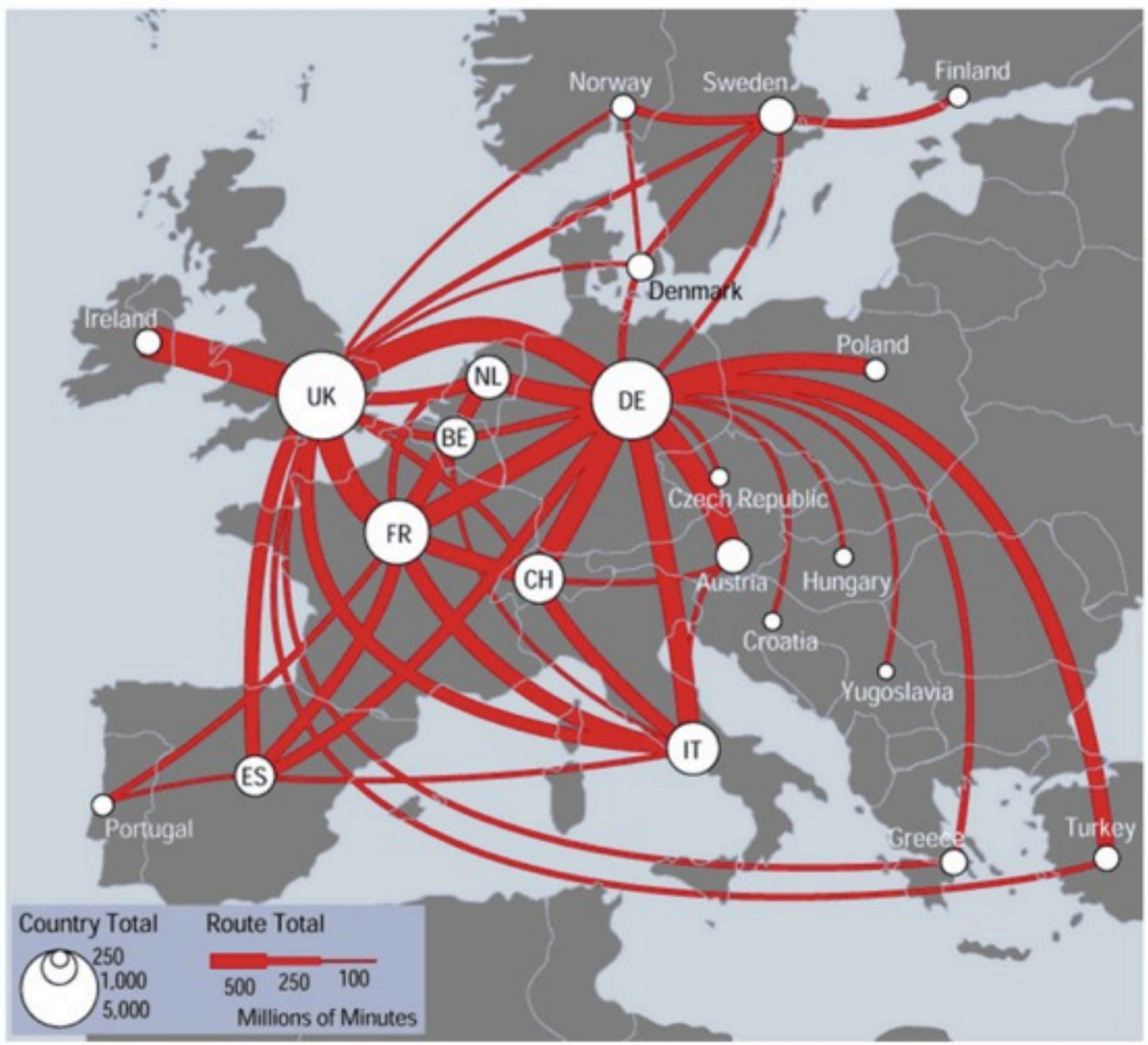


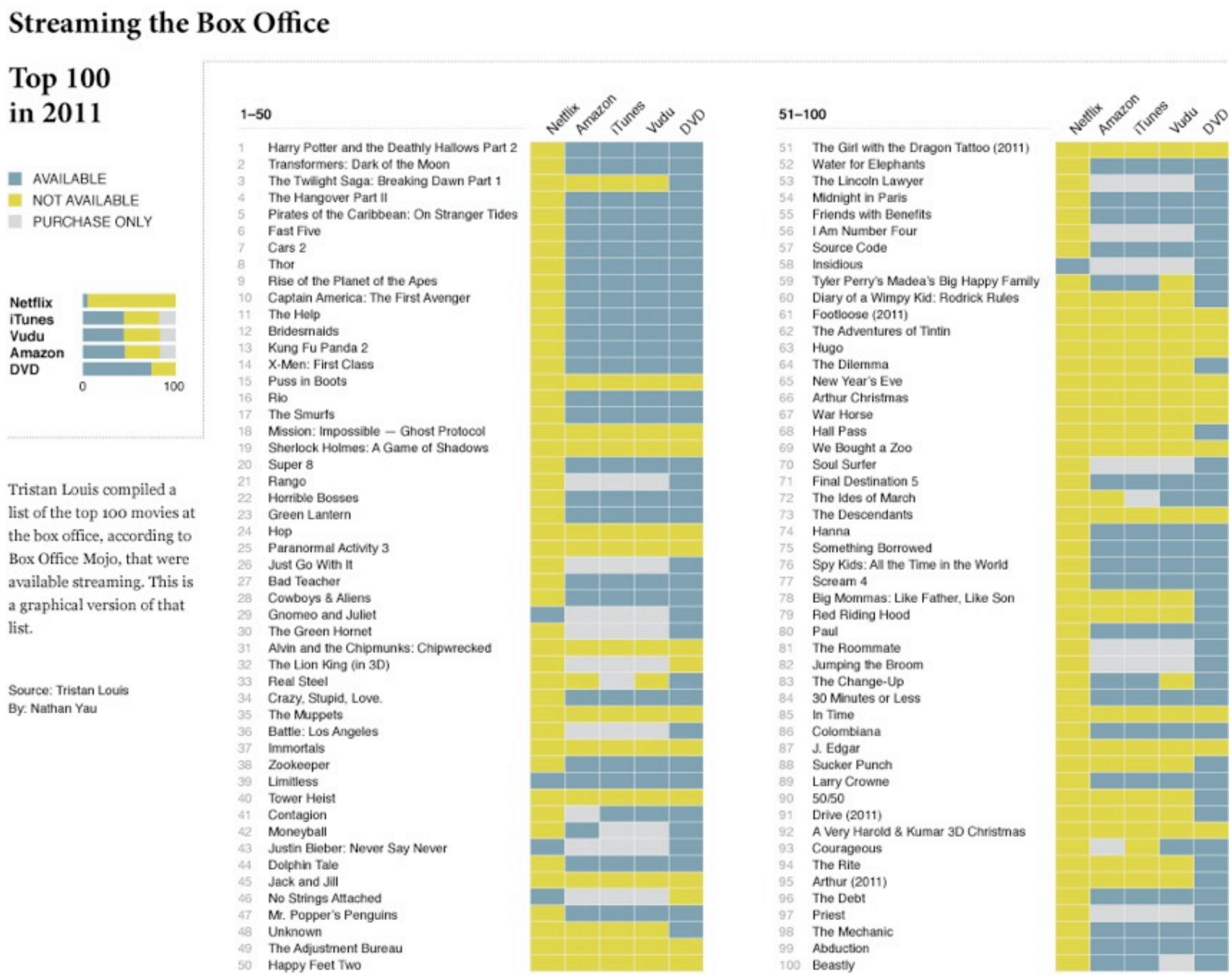


Stevens' Psychophysical Power Law: S = I^n
Electric Current, n = 3.5
Red-Grey Saturation, n = 1.7
Greyscale Luminance Contrast, n = 1.2
Length, n = 1.0
Area, n = .7
Loudness, n = .67
Brightness (Point Source), n = .5
Perceived Sensation
Physical Intensity
0
0.5
1
1.5
2
2.5
3
3.5
4

DISCRIMINABILITY

can channel differences be discerned?

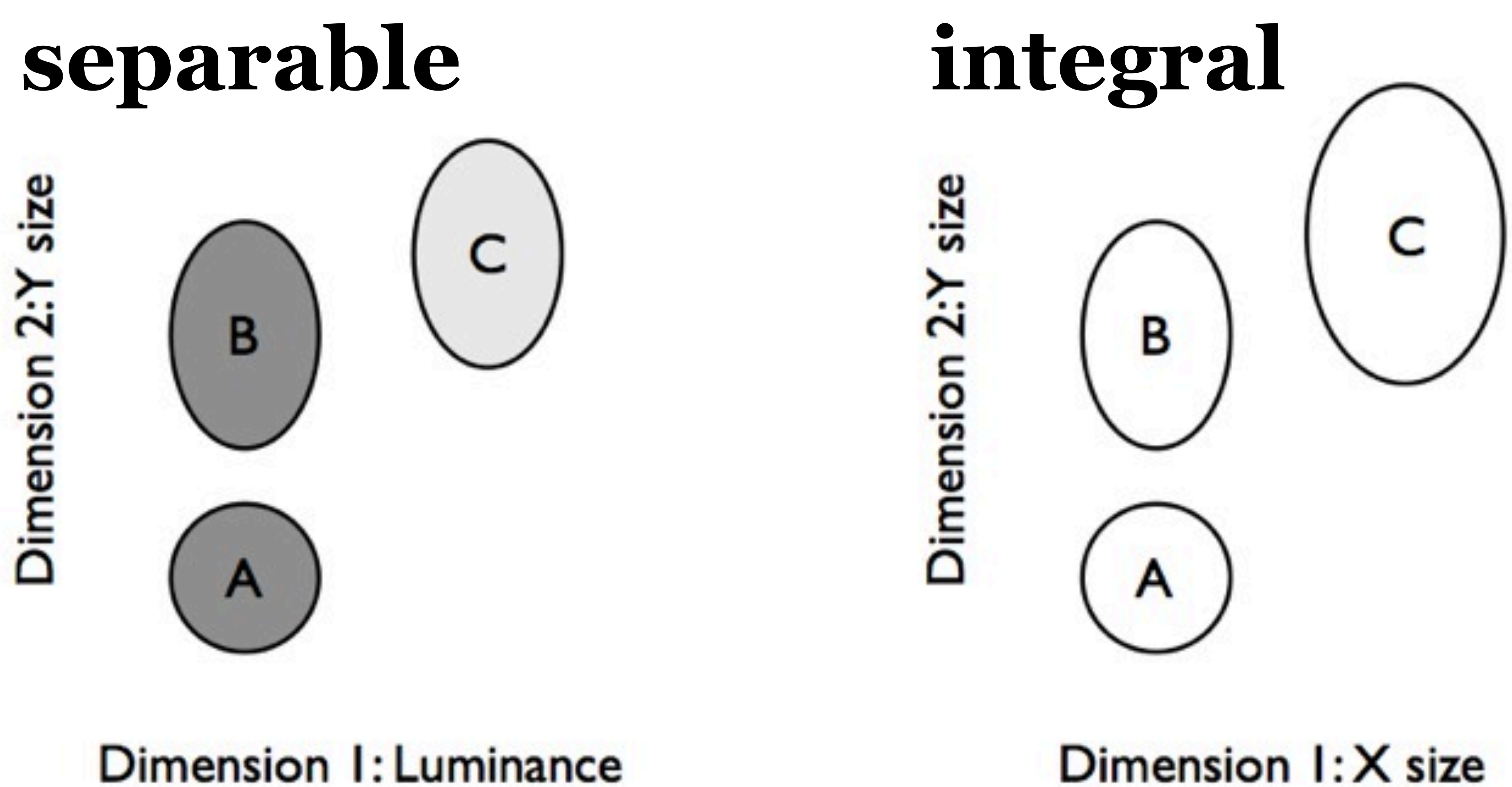




http://flowingdata.com/2012/01/20/where-are-the-biggest-box-office-movies-streaming/

SEPARABLE vs INTEGRAL

- **separable:** can judge each channel individually
- **integral:** two channels are viewed holistically



Ware 2004

SEPARABLE vs INTEGRAL

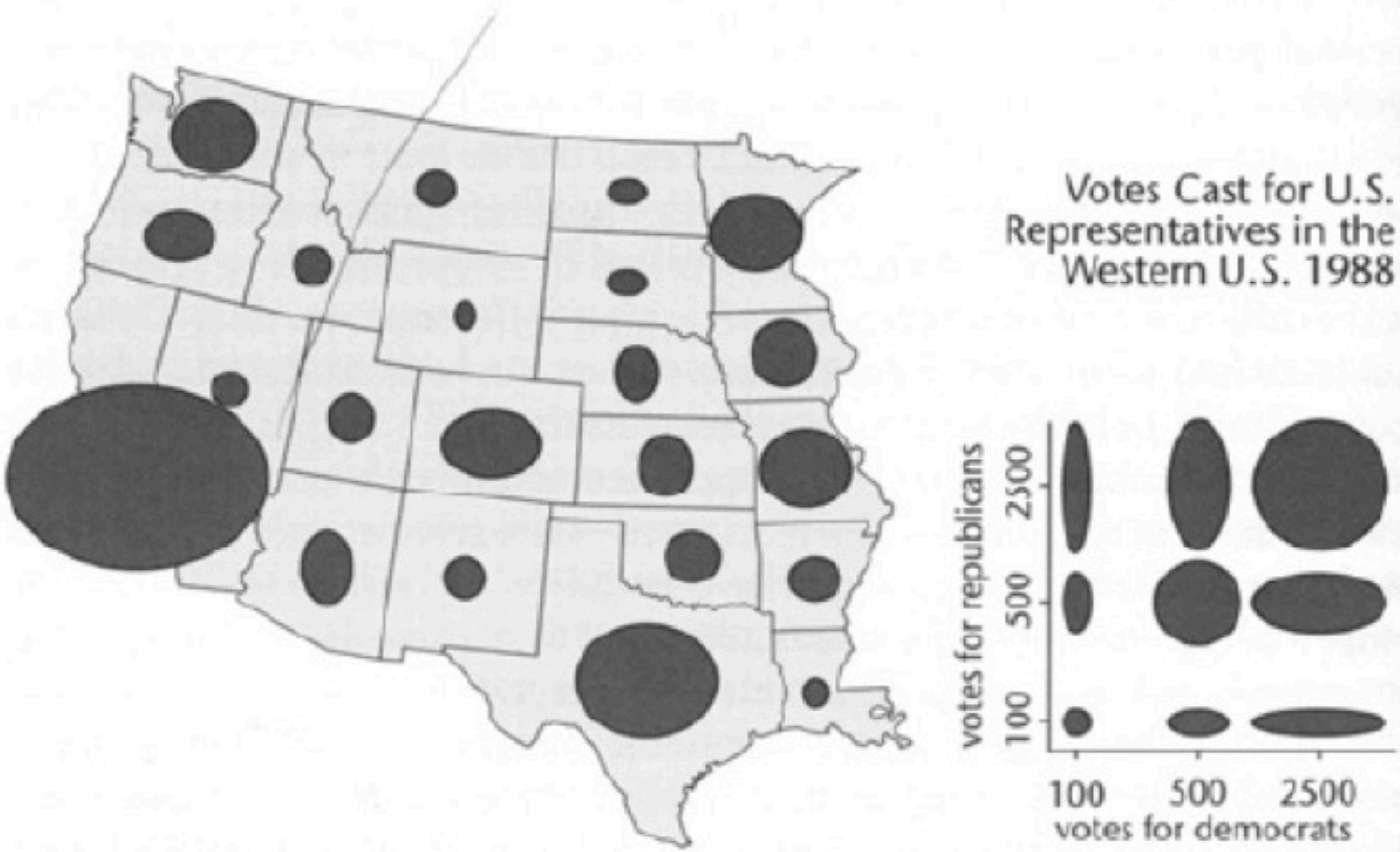


FIGURE 3.38. An example of the use of an ellipse as a map symbol in which the horizontal and vertical axes represent different (but presumably related) variables.

MacEachren 1995

SEPARABLE vs INTEGRAL

separable ⟷ **integral**

color | location

color | motion

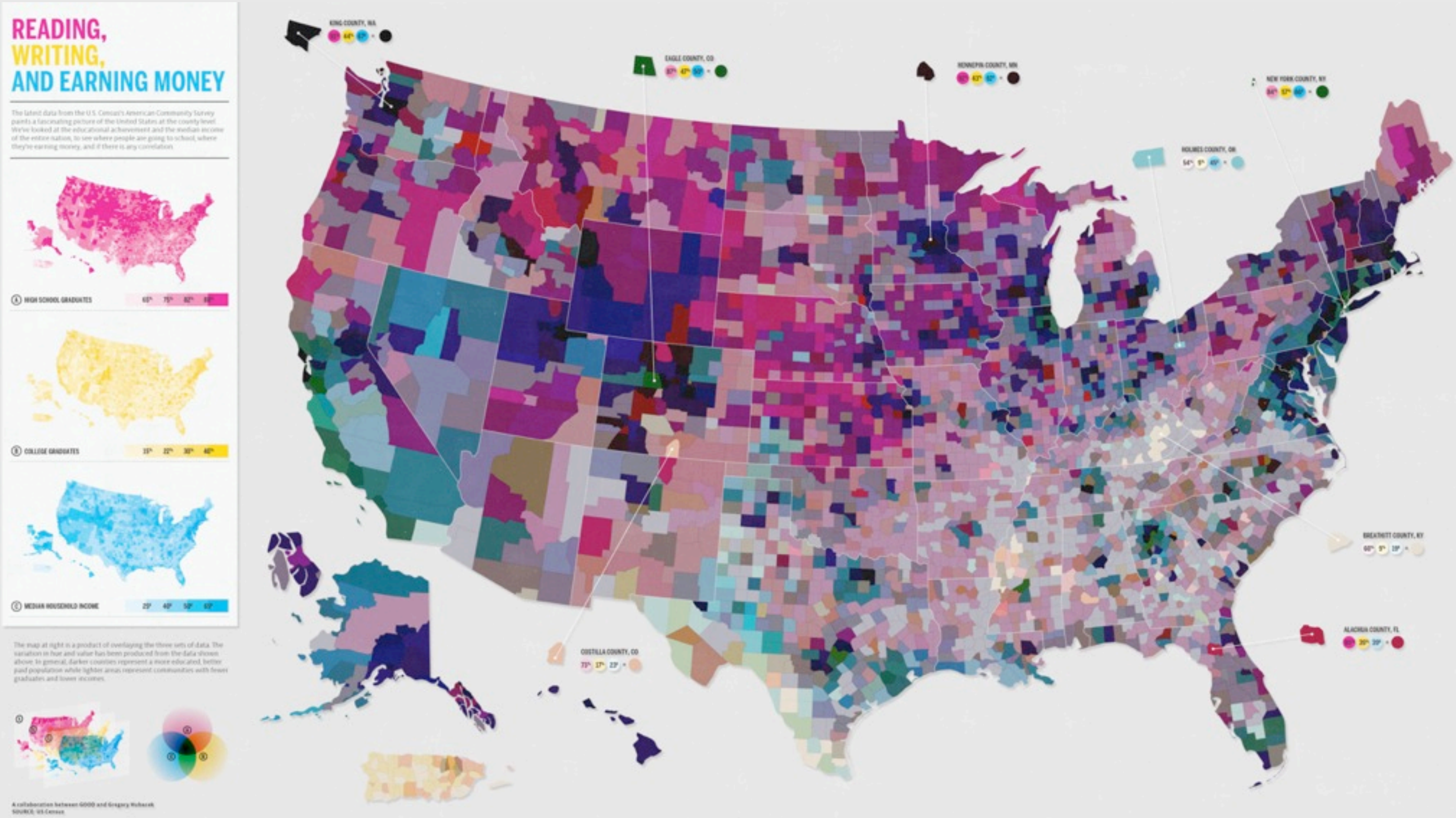
color | shape

size | orientation

x-size | y-size

red-green | yellow-blue

Ware 2004

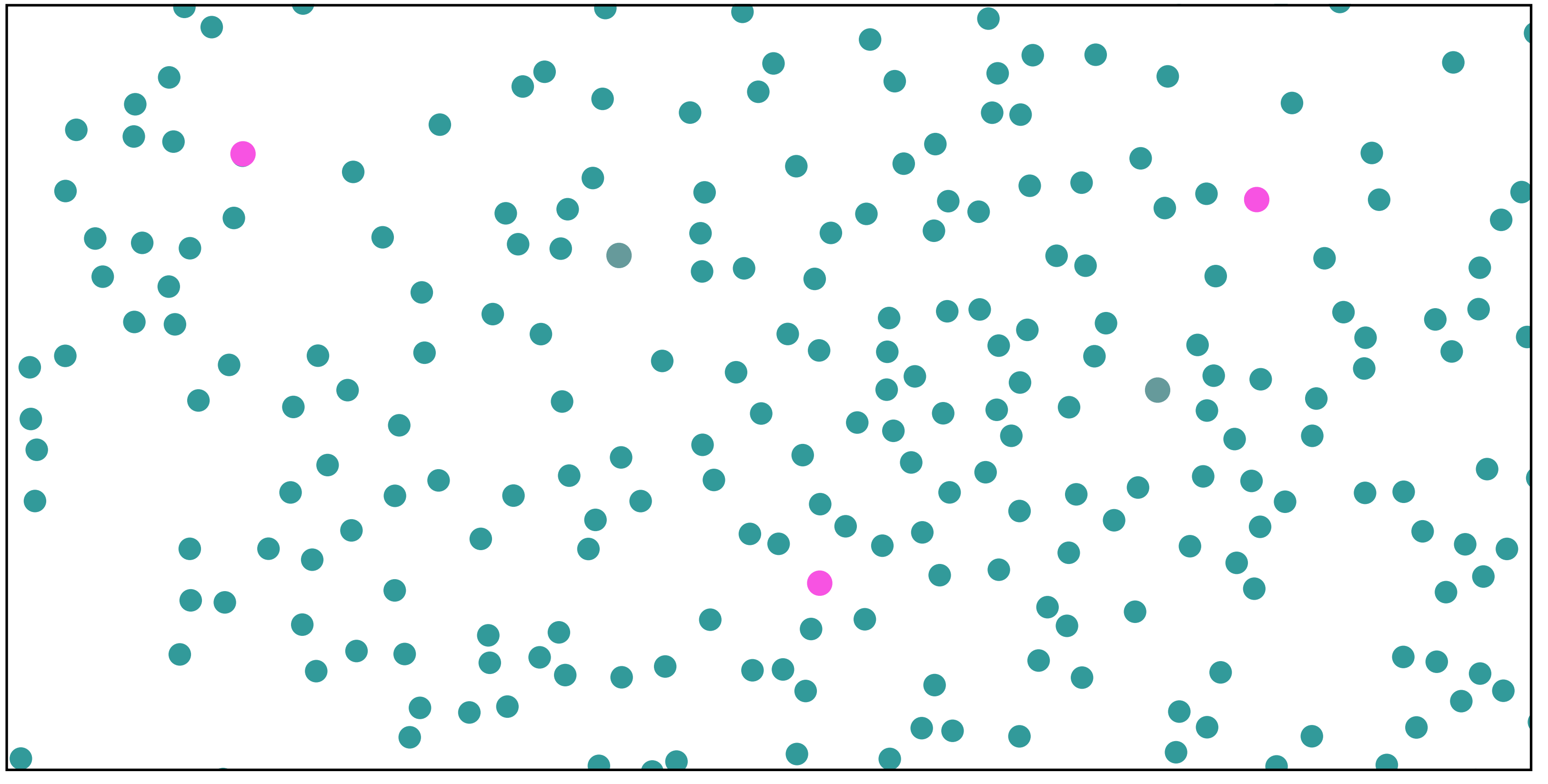


http://www.good.is/post/america-s-richest-counties-and-best-educated-counties/

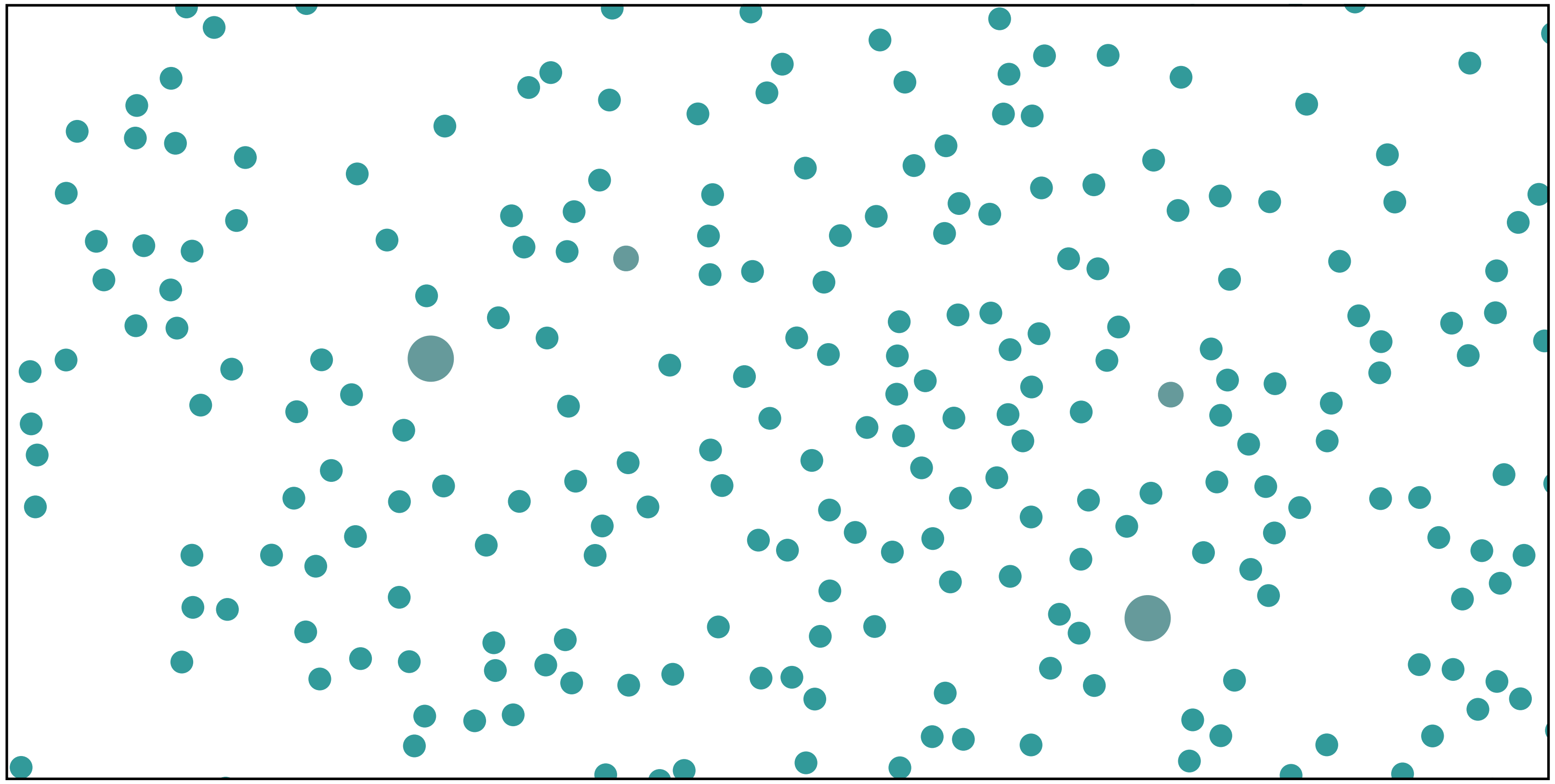
PRE-ATTENTIVE PROCESSING

- **requires attention, despite name**
- **very fast: <200 ms**
- **what matters most is contrast between features**

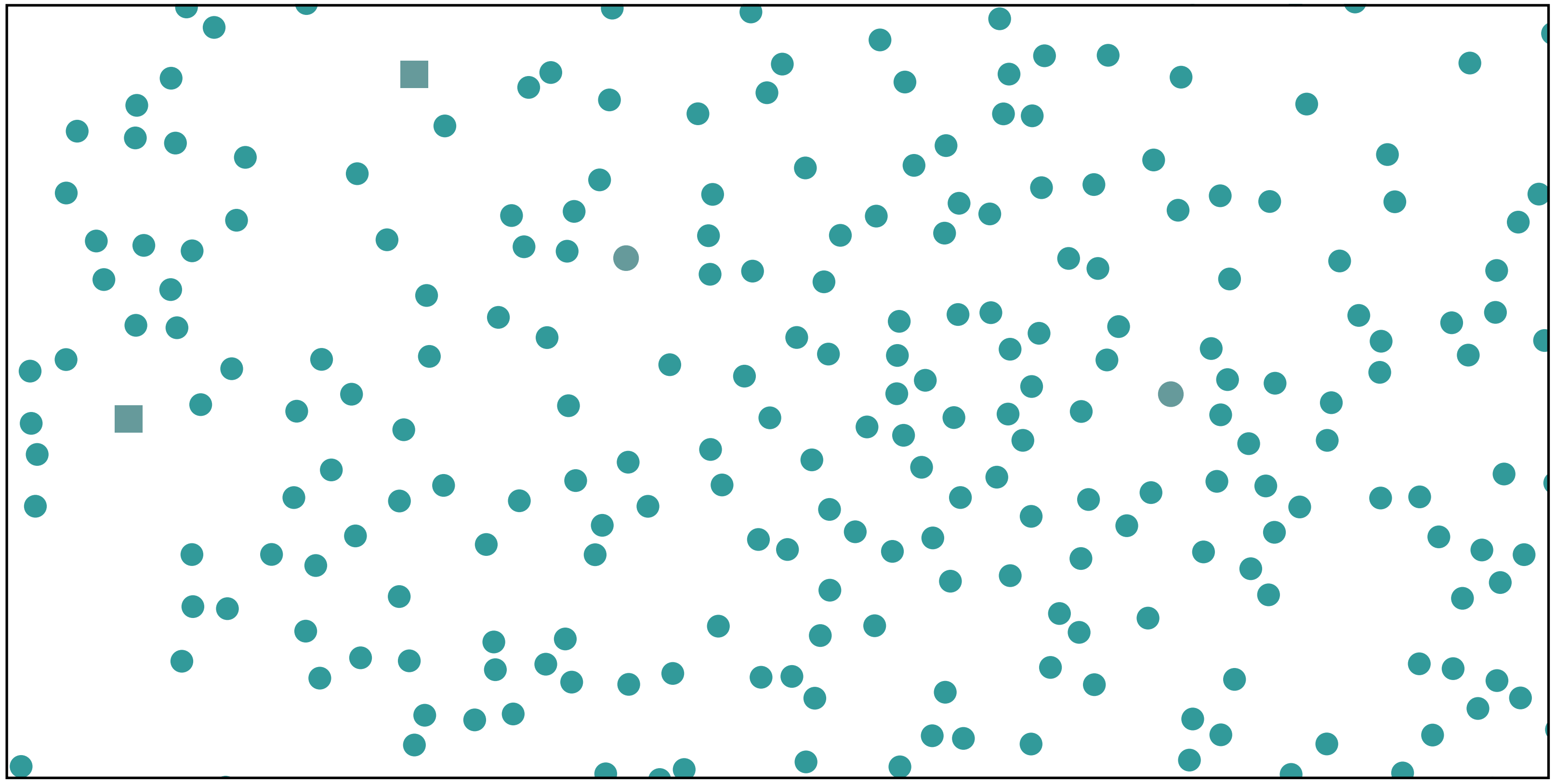
POPOUT



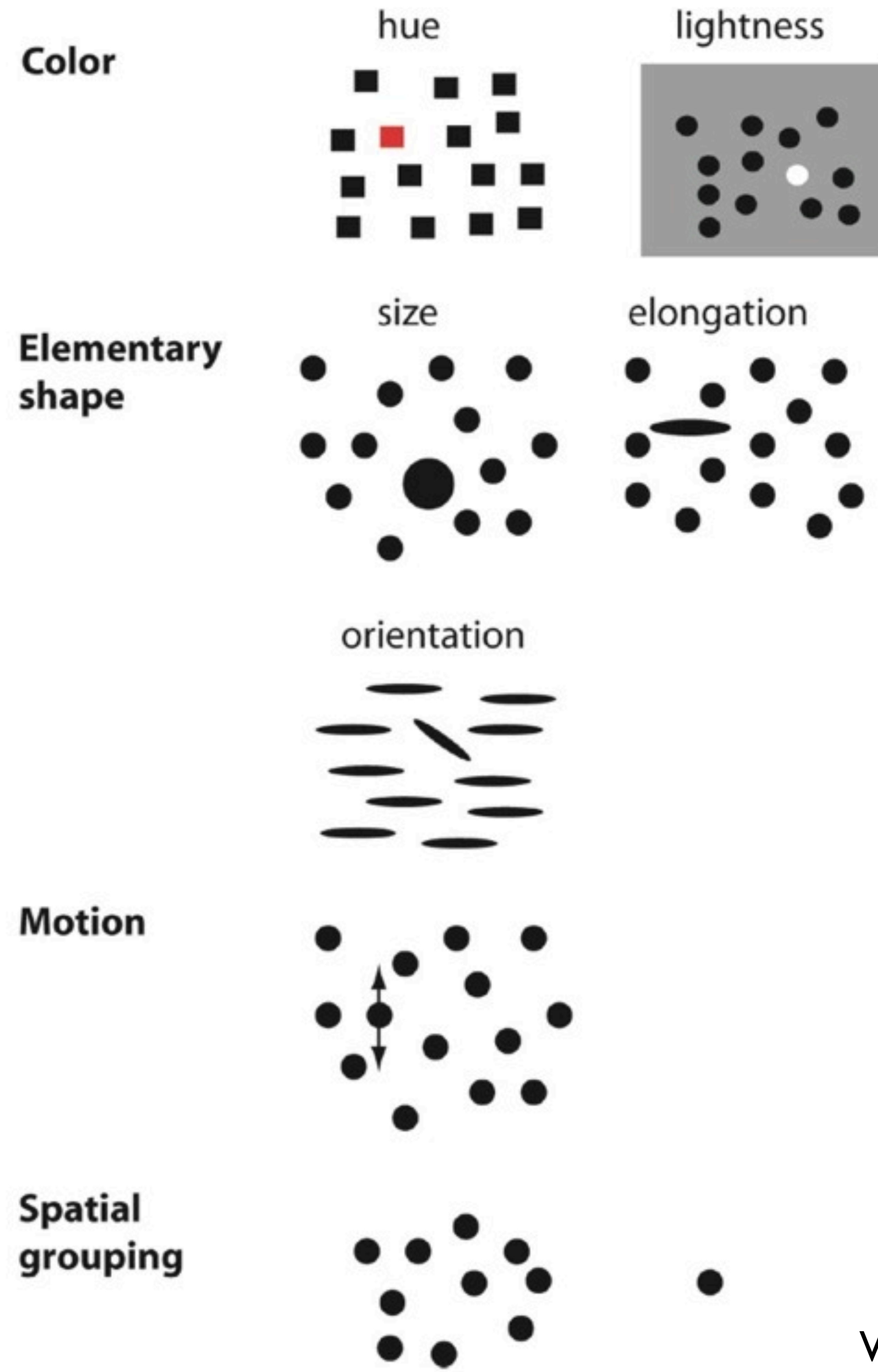
POPOUT



POPOUT

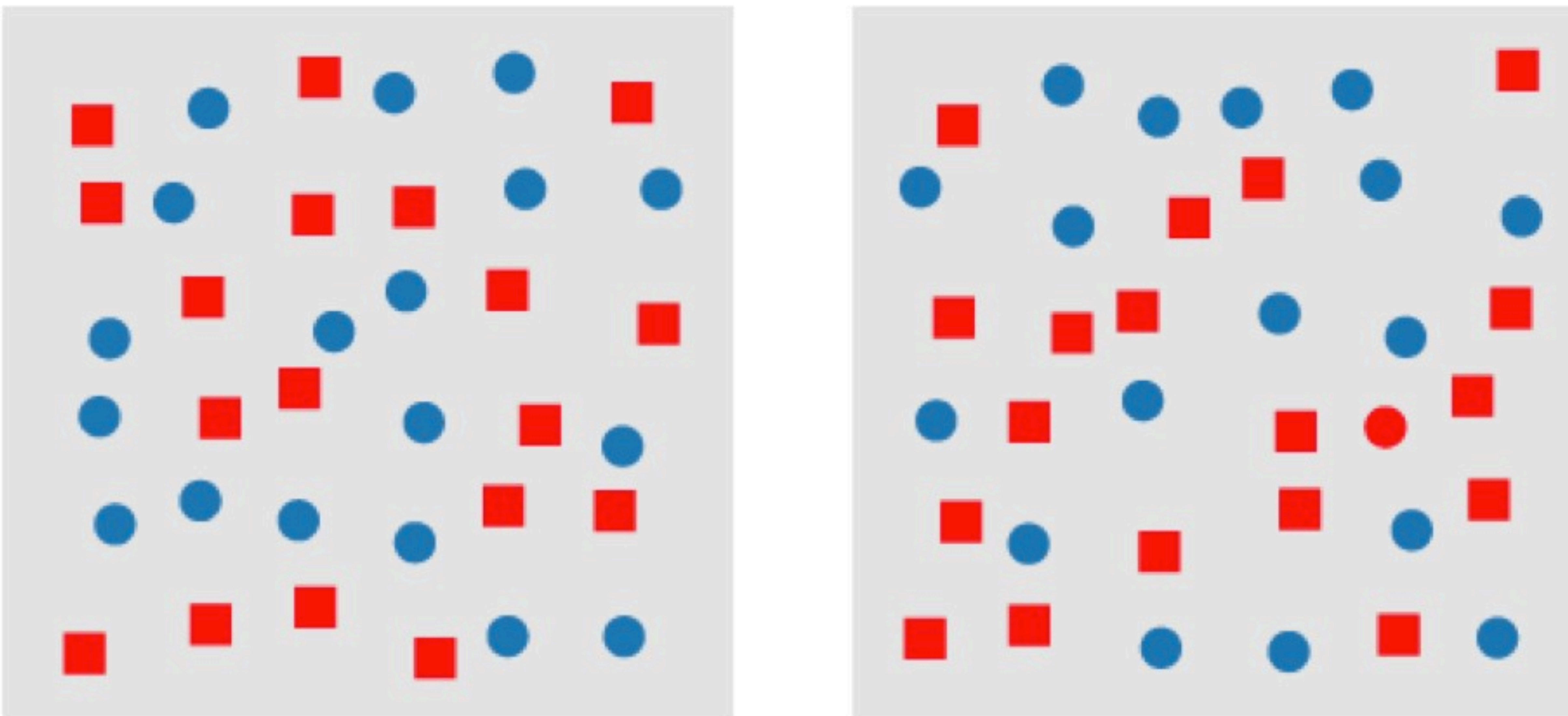


BASIC POPOUT CHANNELS



Ware 2008

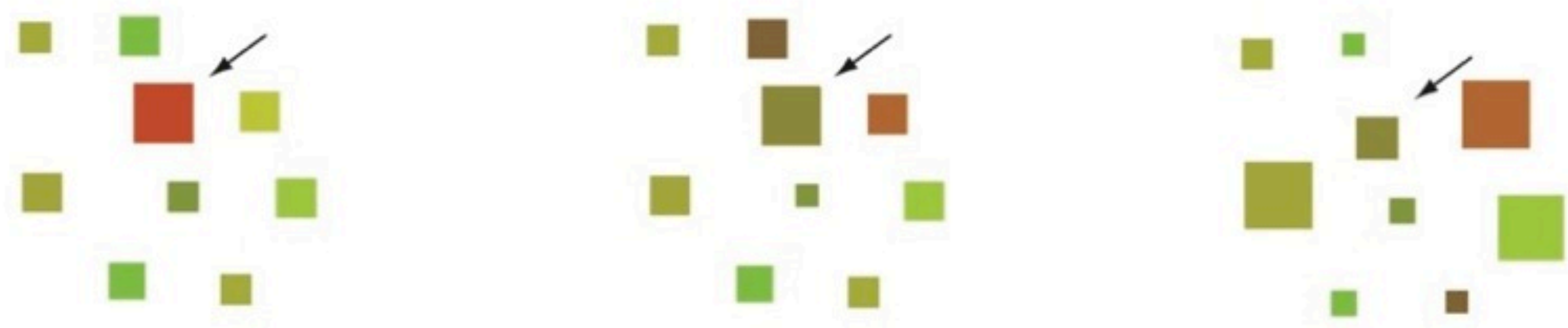
CONJUNCTION
or, why to use a single channel at a time



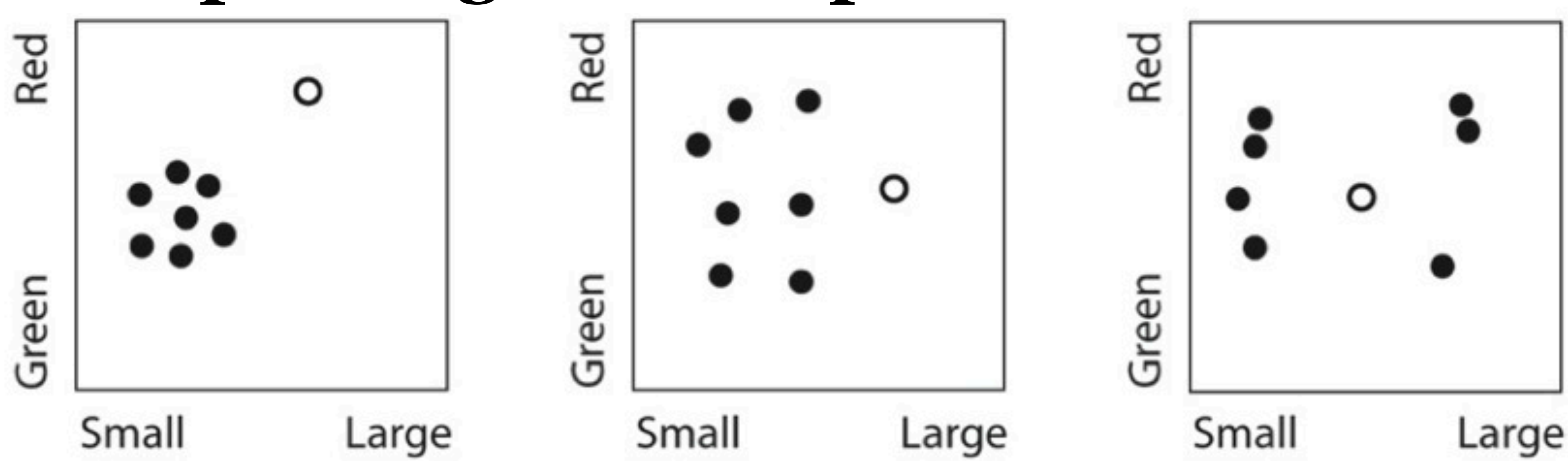
Healey 2007

CONJUNCTION

objects to be searched

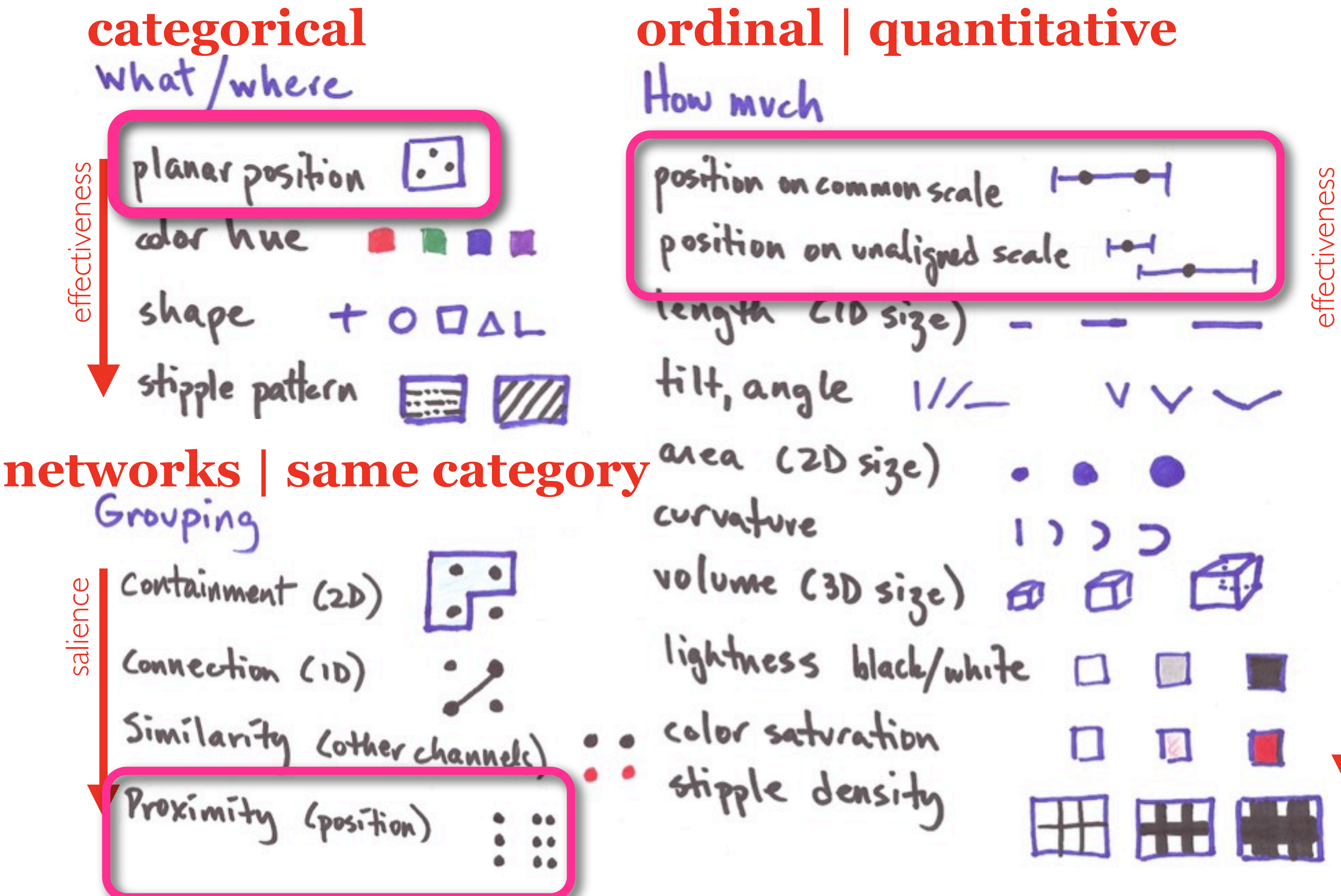


corresponding feature space



- relativity of perception
- marks and channels
- **planar position**
- color

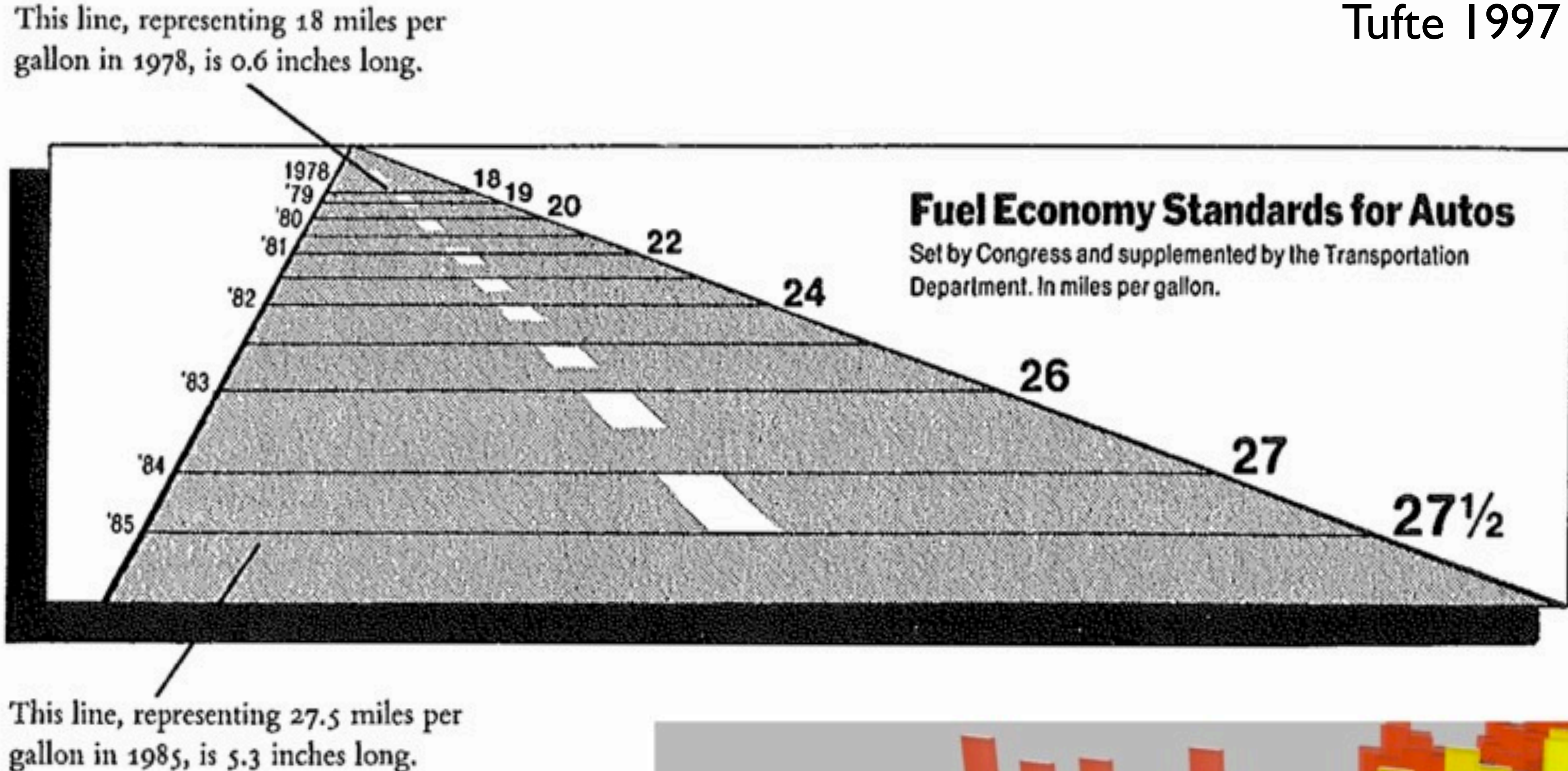
WHAT'S SO SPECIAL ABOUT THE PLANE?

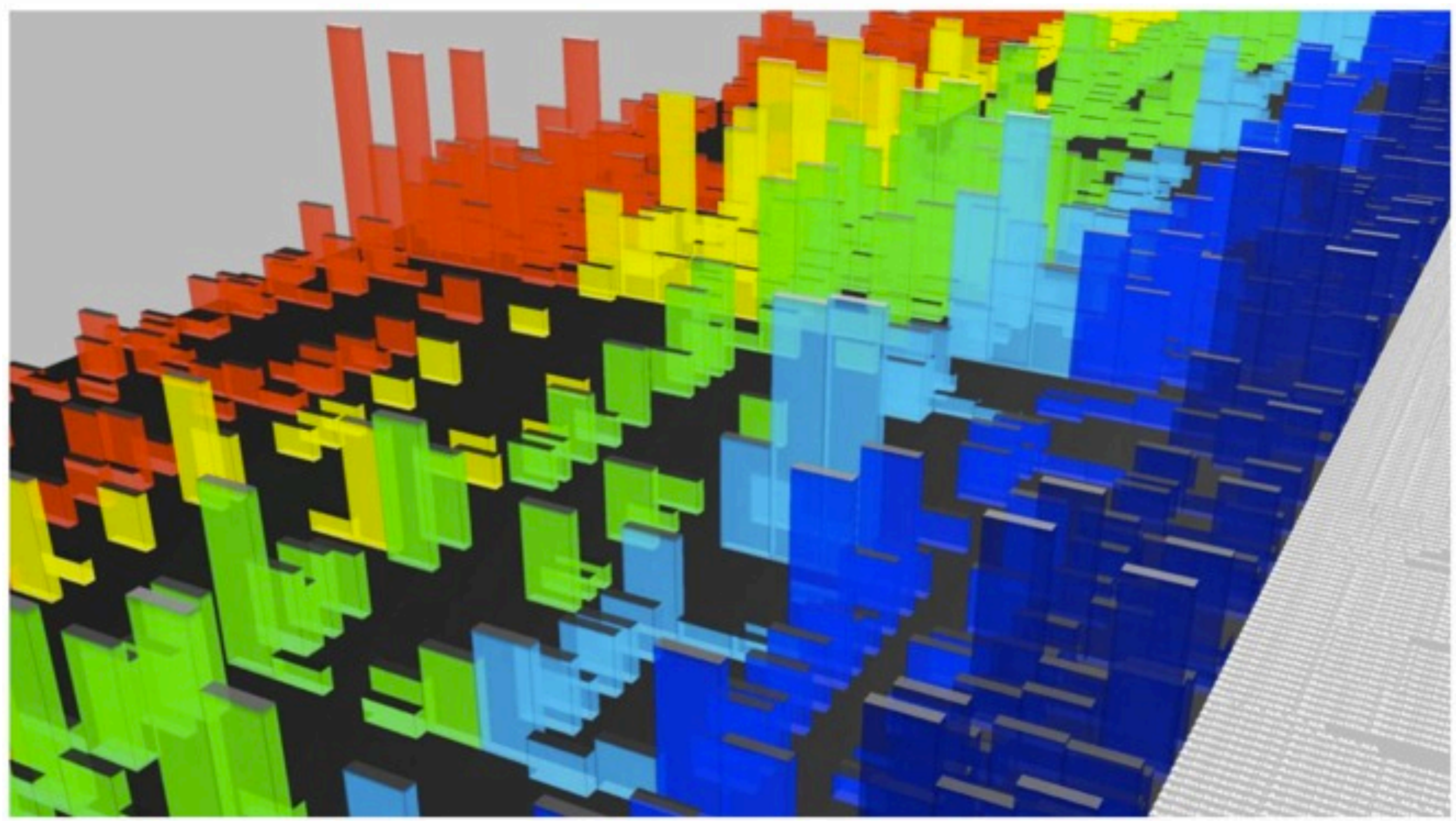


categorical
what/where
planar position
color hue
shape
stipple pattern
effectiveness
ordinal | quantitative
How much
position on common scale
position on unaligned scale
length (1D size)
tilt, angle
area (2D size)
curvature
volume (3D size)
lightness black/white
color saturation
stipple density
effectiveness
networks | same category
Grouping
Containment (2D)
Connection (1D)
Similarity (other channels)
Proximity (position)
salience

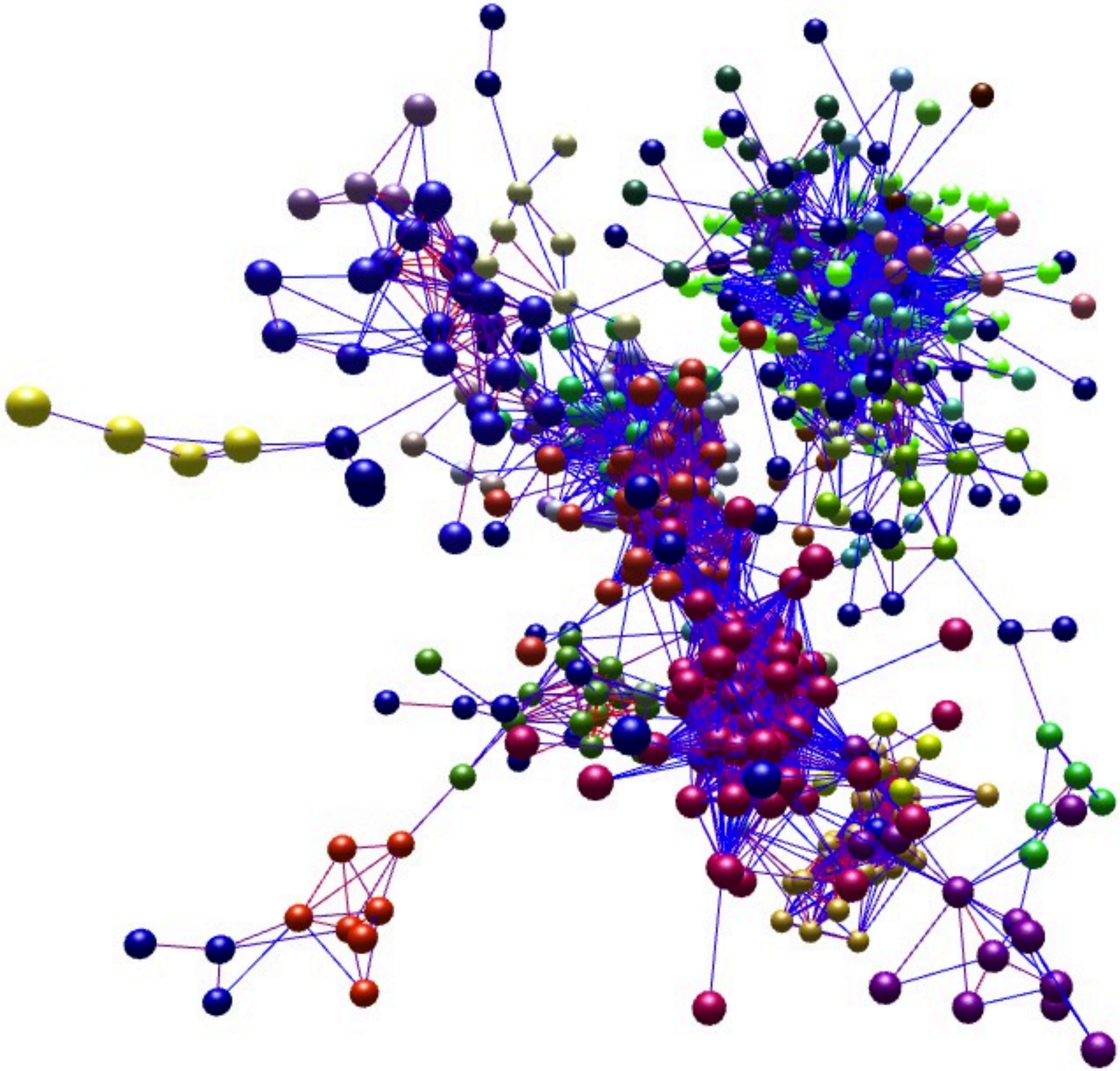
- **power does not extend to 3D**
  - perspective cues
    - *interfere with color and size channels*
  - occlusion of data

Tufte 1997



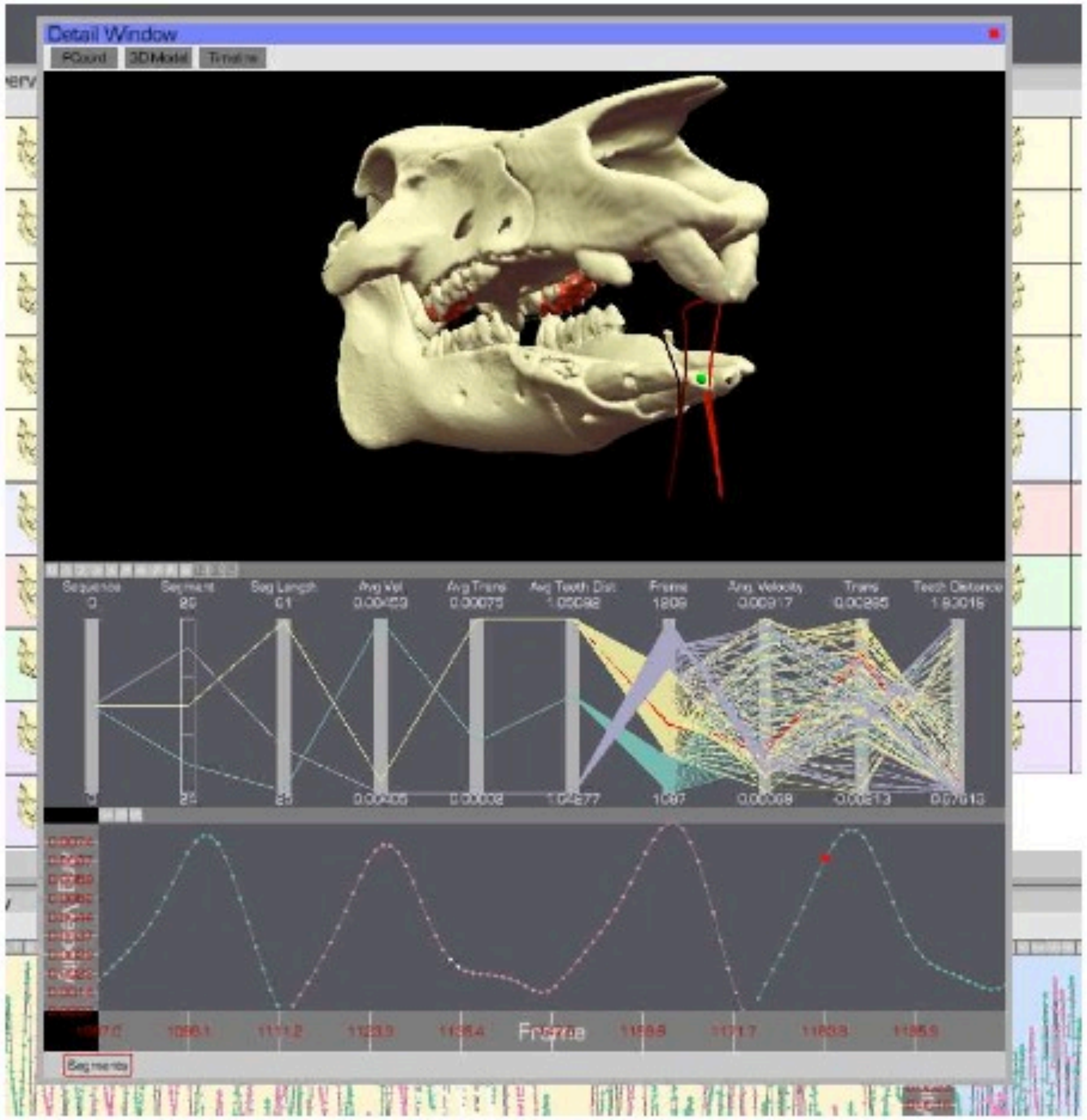


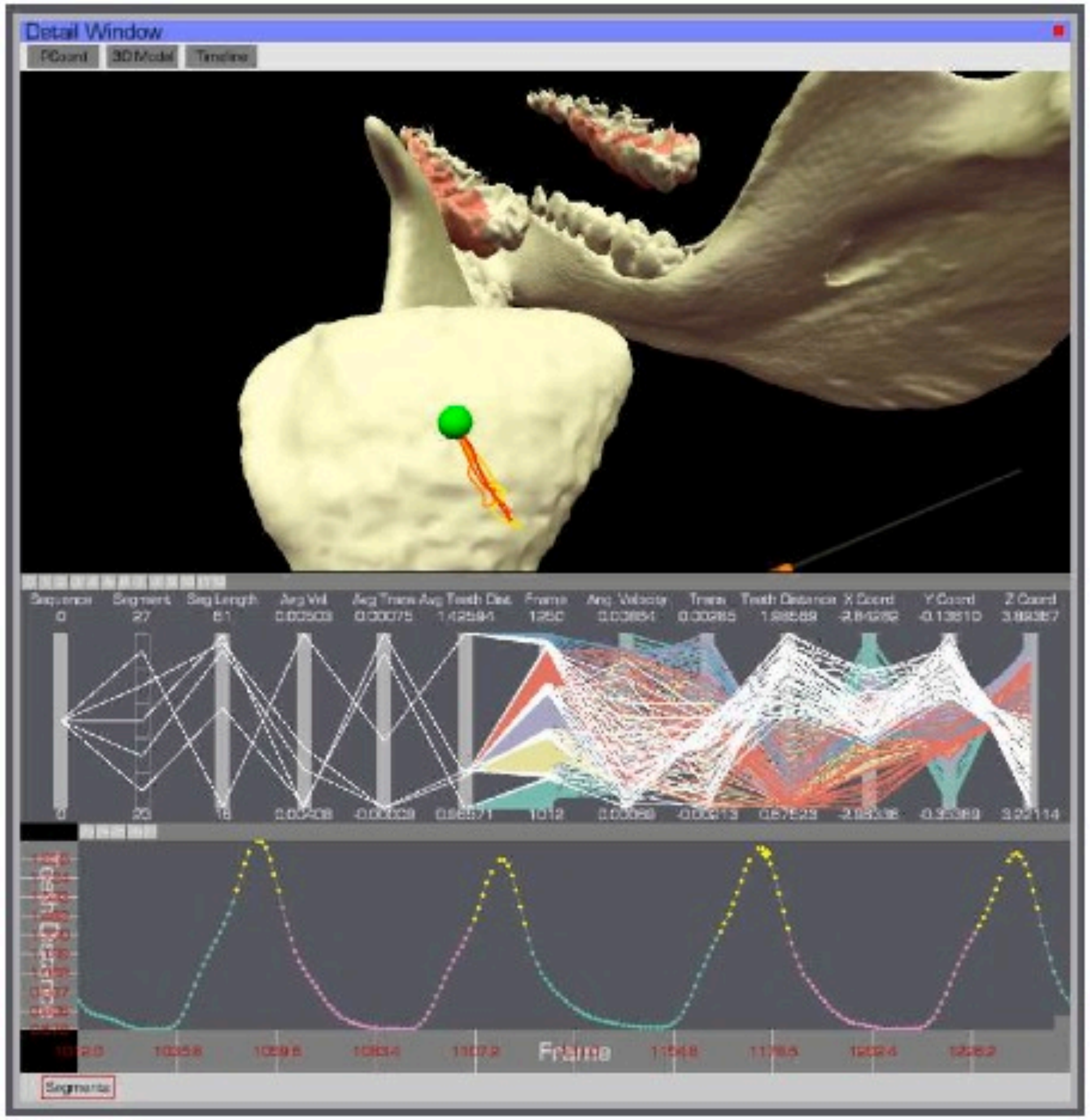
Moore 2011



http://www.biolayout.org/

2D and 3D?



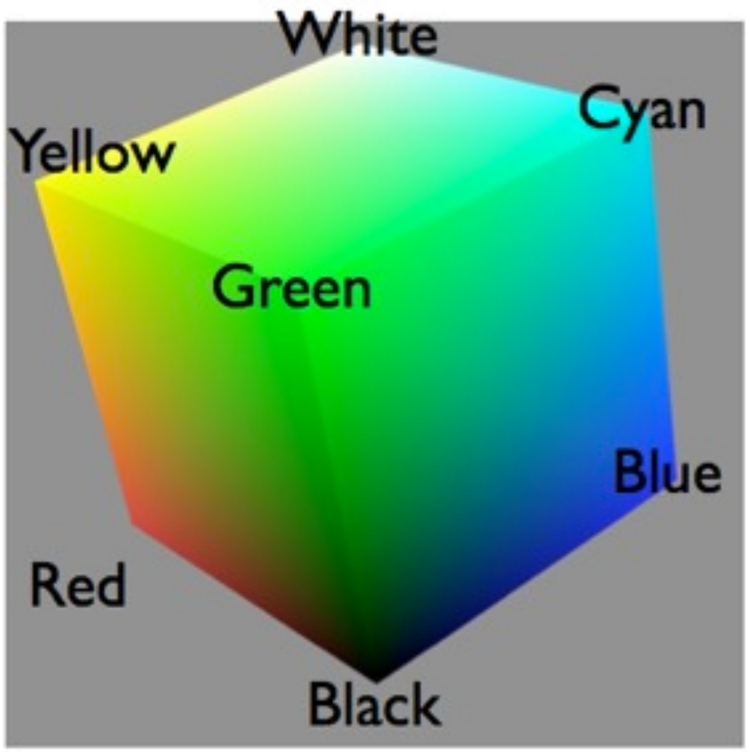


Keefe 2008

- **relativity of perception**
- **marks and channels**
- **planar position**
- **color**

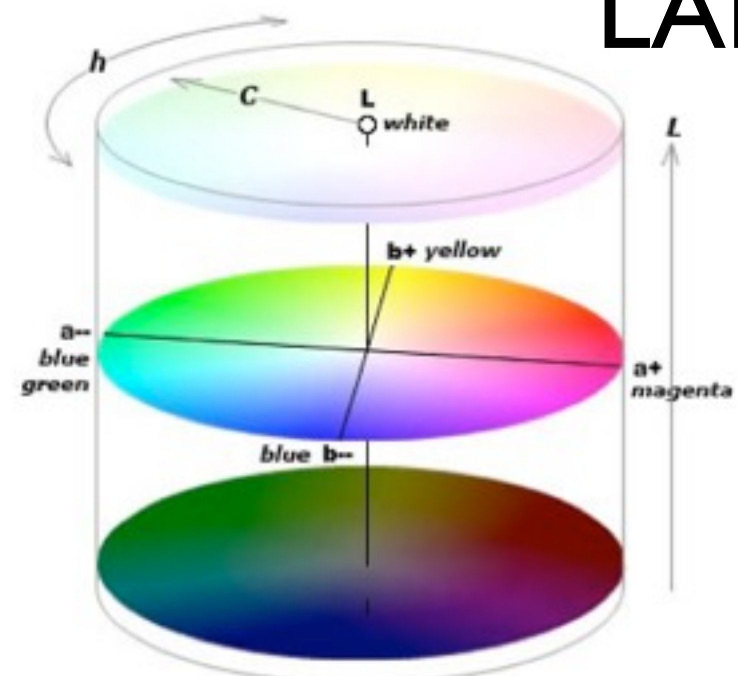
WHY IS COLOR SO HARD TO USE?

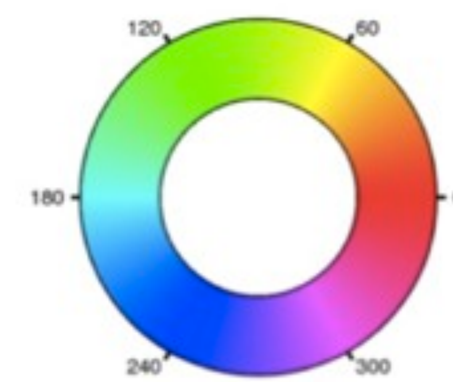
obtaining a perceptually uniform color space is challenging



RGB
not uniform

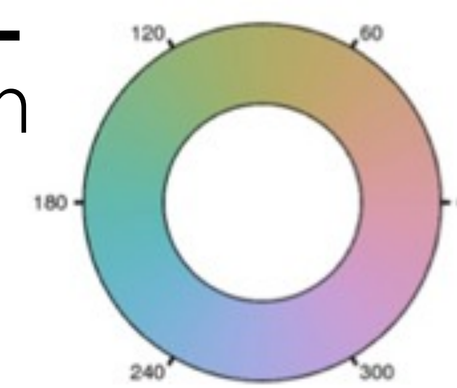
LAB | LUV
uniform



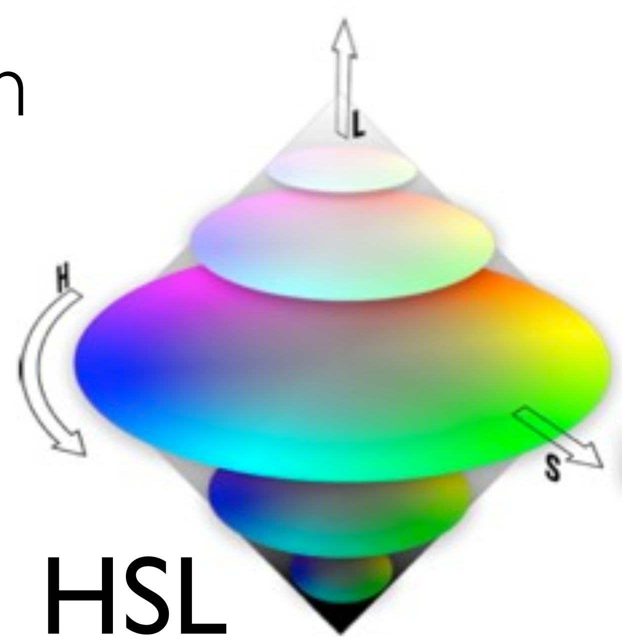


HSL

HCL
uniform



HCL

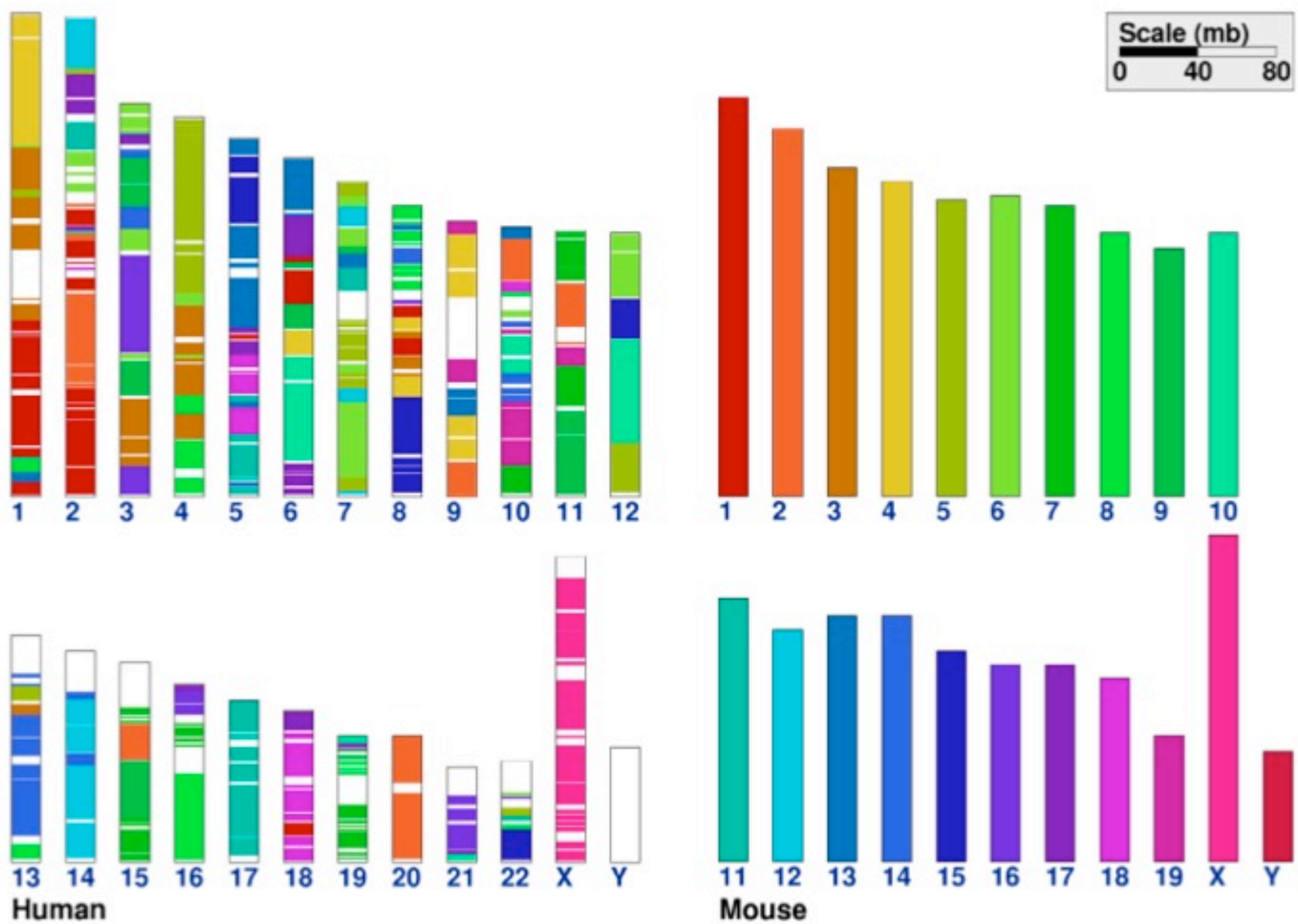


HSL
not uniform

color interactions

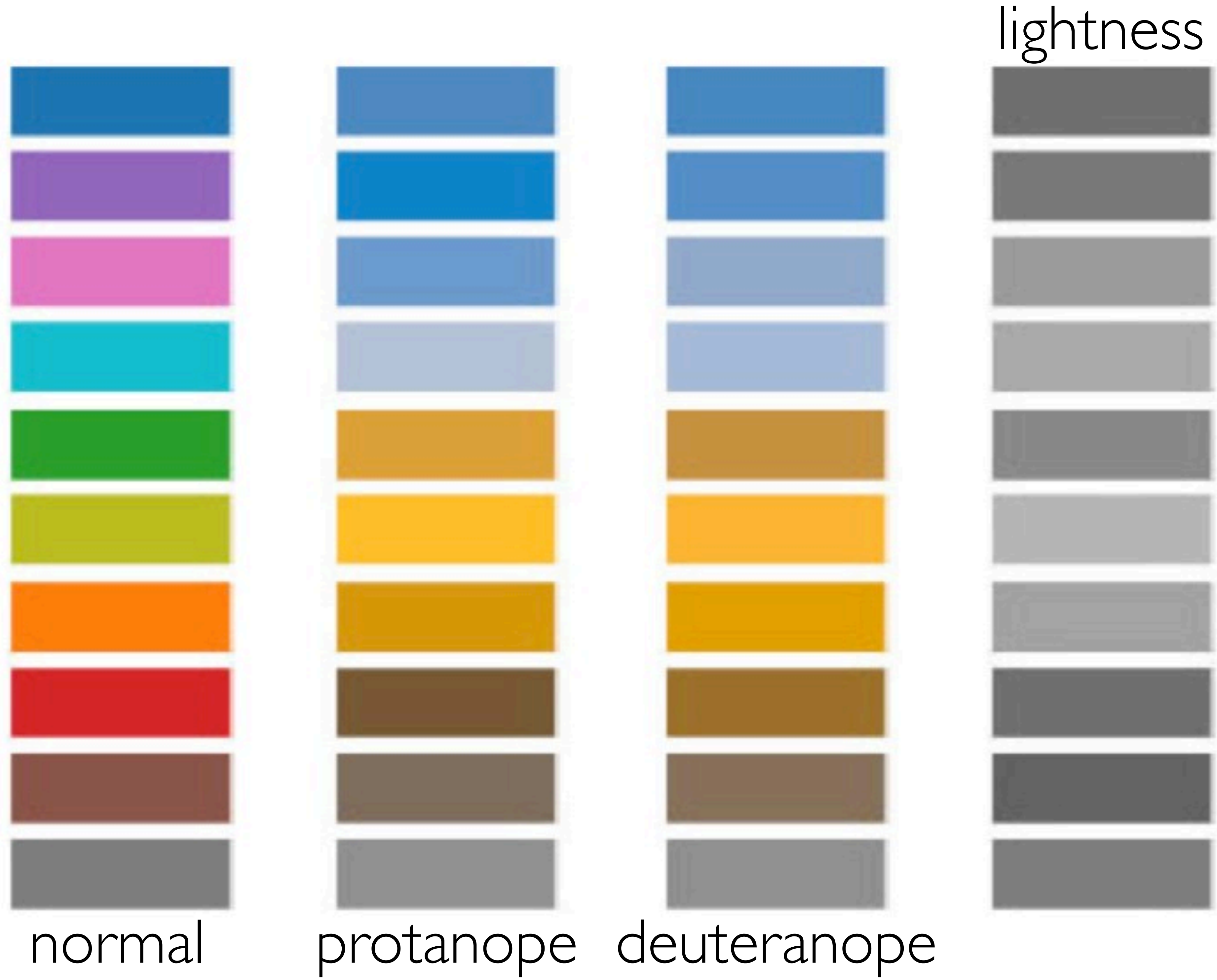
Wong 2010

color discriminability

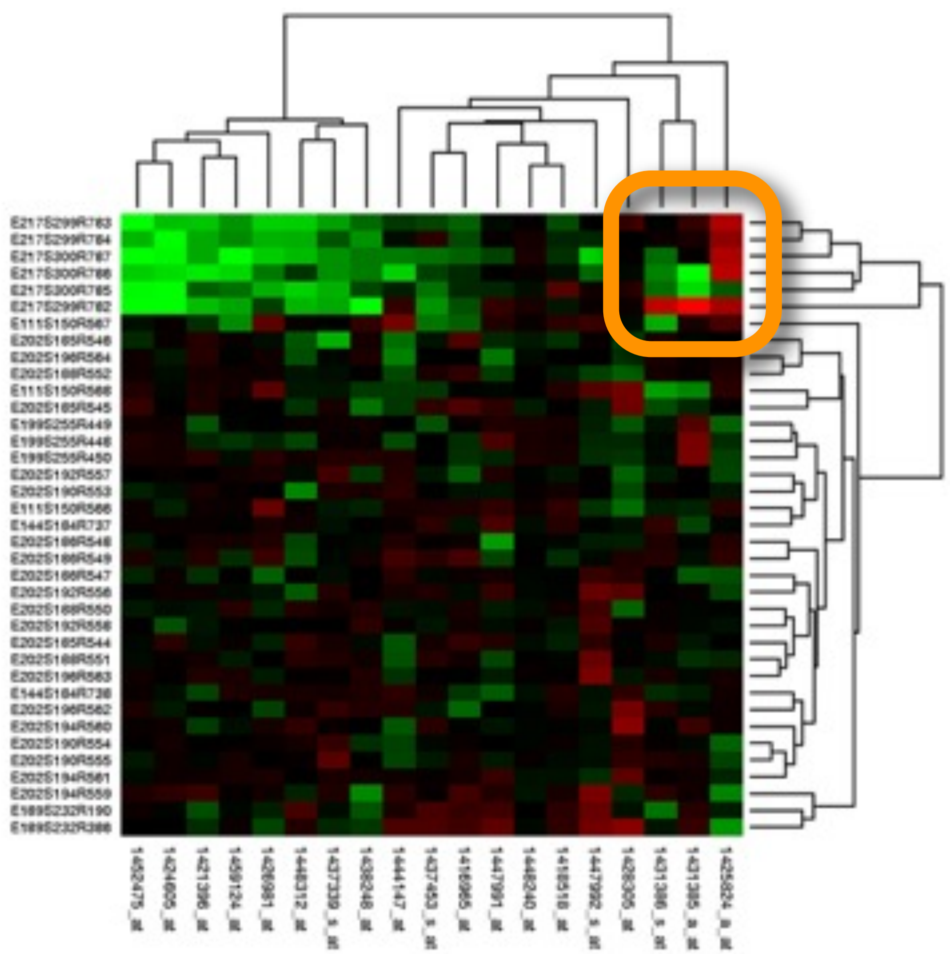


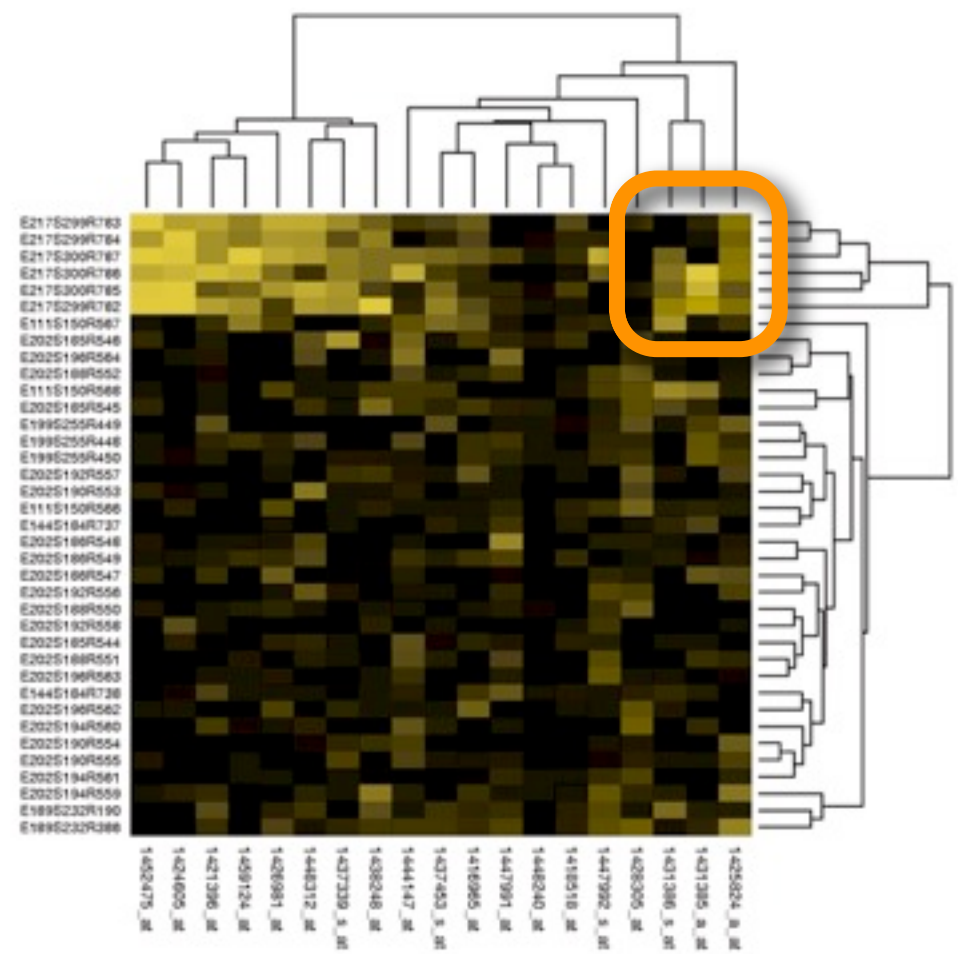
Sinha 2007

color blindness

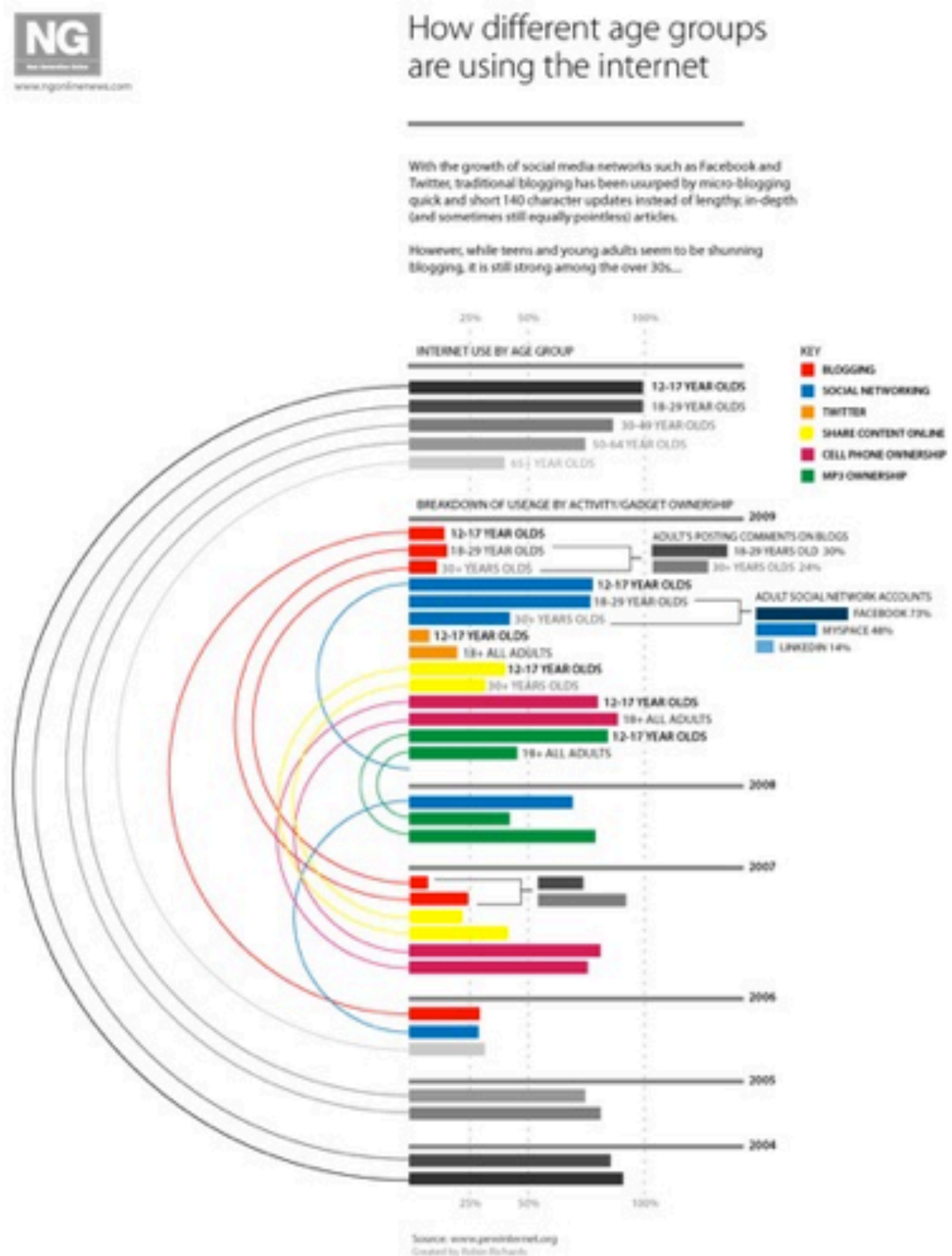


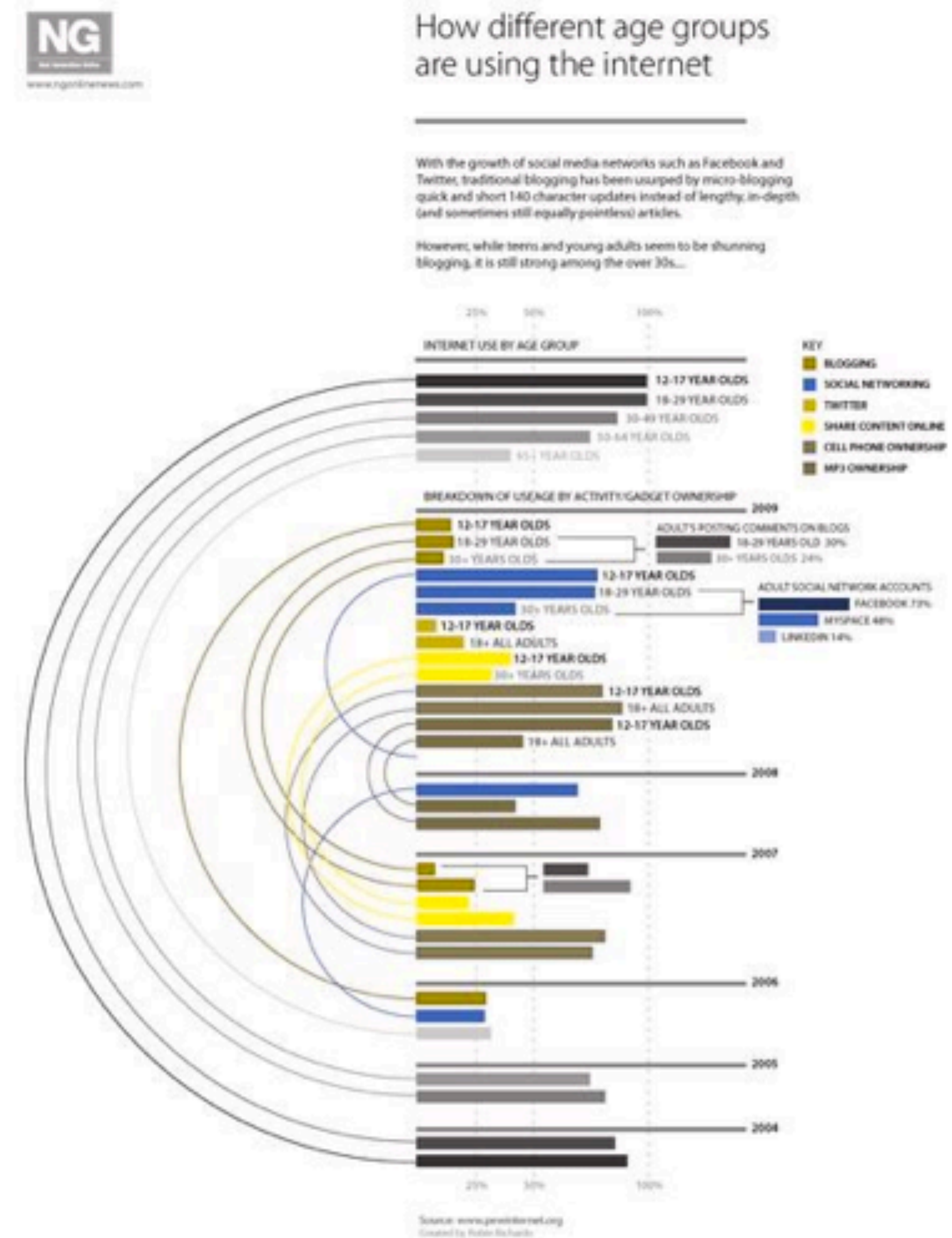
color blindness






Vischeck: VischeckURL
http://www.vischeck.com/vischeck/vischeckURL.php
Google
A Historic ...NYTimes.com
untitled folder
cs171
Harvard Google Scholar
Apple
Yahoo!
Google Maps
YouTube
Wikipedia
http://www.cs.ubc.ca/~tmm/cou...
CS6964 | Information Visualization
Vischeck: VischeckURL
Vischeck
ROMNEY
BELIEVE IN AMERICA
Let's fight for the
AMERICA WE LOVE.
DONATE
Paid for by Romney for President, Inc.
Home
Vischeck
·Run Images
·Run Webpages
Daltonize
Examples
Downloads
Info & Links
FAQ
About Us
User quotes:
Just a note of thanks for providing an excellent site (or maybe that should be sight!). As a human-computer interaction educator, I've tried to tell students about these issues for years, with little success because of a lack of useful simulations. Your site will become a standard assignment for my course from now on. I also happen to be colorblind (red/green).
Try Vischeck on a Webpage
Select the type of color vision to simulate:
Deuteranope (a form of red/green color deficit)
Protanope (another form of red/green color deficit)
Tritanope (a blue/yellow deficit- very rare)
Enter the URL of any webpage- eg. www.google.com.
URL:
Run Vischeck!
Notes:
Vischeck URL is still under development. We know that it will fail on many websites. For example, it won't work with sites that do an immediate redirect, use Macromedia Flash, or use certain javascript operations. Frames may also cause problems, but you can run each frame separately to get around this.
Style sheets are crudely supported but beware that many variants will give


NG
How different age groups
are using the internet
With the growth of social media networks such as Facebook and Twitter, traditional blogging has been usurped by micro-blogging quick and short 140 character updates instead of lengthy, in-depth (and sometimes still equally pointless) articles.
However, while teens and young adults seem to be shunning blogging, it is still strong among the over 30s...
INTERNET USE BY AGE GROUP
12-17 YEAR OLDS
18-29 YEAR OLDS
30-49 YEAR OLDS
50-64 YEAR OLDS
65+ YEAR OLDS
KEY
BLOGGING
SOCIAL NETWORKING
TWITTER
SHARE CONTENT ONLINE
CELL PHONE OWNERSHIP
MP3 OWNERSHIP
BREAKDOWN OF USEAGE BY ACTIVITY/GADGET OWNERSHIP
2009
ADULT'S POSTING COMMENTS ON BLOGS
18-29 YEARS OLD 30%
30+ YEARS OLDS 24%
ADULT SOCIAL NETWORK ACCOUNTS
FACEBOOK 73%
MYSPACE 48%
LINKEDIN 14%
18+ ALL ADULTS
2008
2007
2006
2005
2004
25%
50%
100%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MP3 OWNERSHIP
BREAKDOWN OF USEAGE BY ACTIVITY/GADGET OWNERSHIP
2009
2008
2007
2006
2005
2004

RECOMMENDED READING

Visualization Viewpoints

Editor: Theresa-Marie Rhyne

Rainbow Color Map (Still) Considered Harmful

David Borland and Russell M. Taylor II
University of North Carolina at Chapel Hill

Research has shown that the rainbow color map is rarely the optimal choice when displaying data with a pseudocolor map. The rainbow color map confuses viewers through its lack of perceptual ordering, obscures data through its uncontrolled luminance variation, and actively misleads interpretation through the introduction of non-data-dependent gradients.

Despite much published research on its deficiencies, the rainbow color map is prevalent in the visualization community. We present survey results showing that the rainbow color map continues to appear in more than half of the relevant papers in IEEE Visualization Conference proceedings; for example, it appeared on 61 [illegible] as the default color map used in most visualization toolkits that we inspected. The visualization community must do better.

In this article, we reiterate the characteristics that make the rainbow color map a poor choice, provide examples that clearly illustrate these deficiencies even on simple data sets, and recommend better color maps for several categories of display.

The goal is to make the rainbow color map as rare in commercials, weather forecasts, and even the IEEE Visualization Conference 2006 call for papers, just to name a few. The problem with this wide use of the rainbow color map is that research shows that it is rarely, if ever, the optimal color map for a given visualization.[1-6] Here we will discuss the rainbow color map's characteristics of confusing the viewer, obscuring data, and actively misleading interpretation.

Confusing

For all tasks that involve comparing relative values, the color map used should exhibit perceptual ordering. A simple example of a perceptually ordered color map is th[illegible]sing luminance from black to white is a strong perceptual cue that indicates values mapped to darker shades of gray are lower in value than values mapped to lighter shades of gray. This mapping is natural and intuitive.

The rainbow color map is certainly ordered—from a shorter to longer wavelength of light (or vice versa)—but it's not perceptually ordered. If people are given a series of gray paint chips and asked to put them in order, they will consistently place them in either a dark-to-light

How NOT to Lie with Visualization

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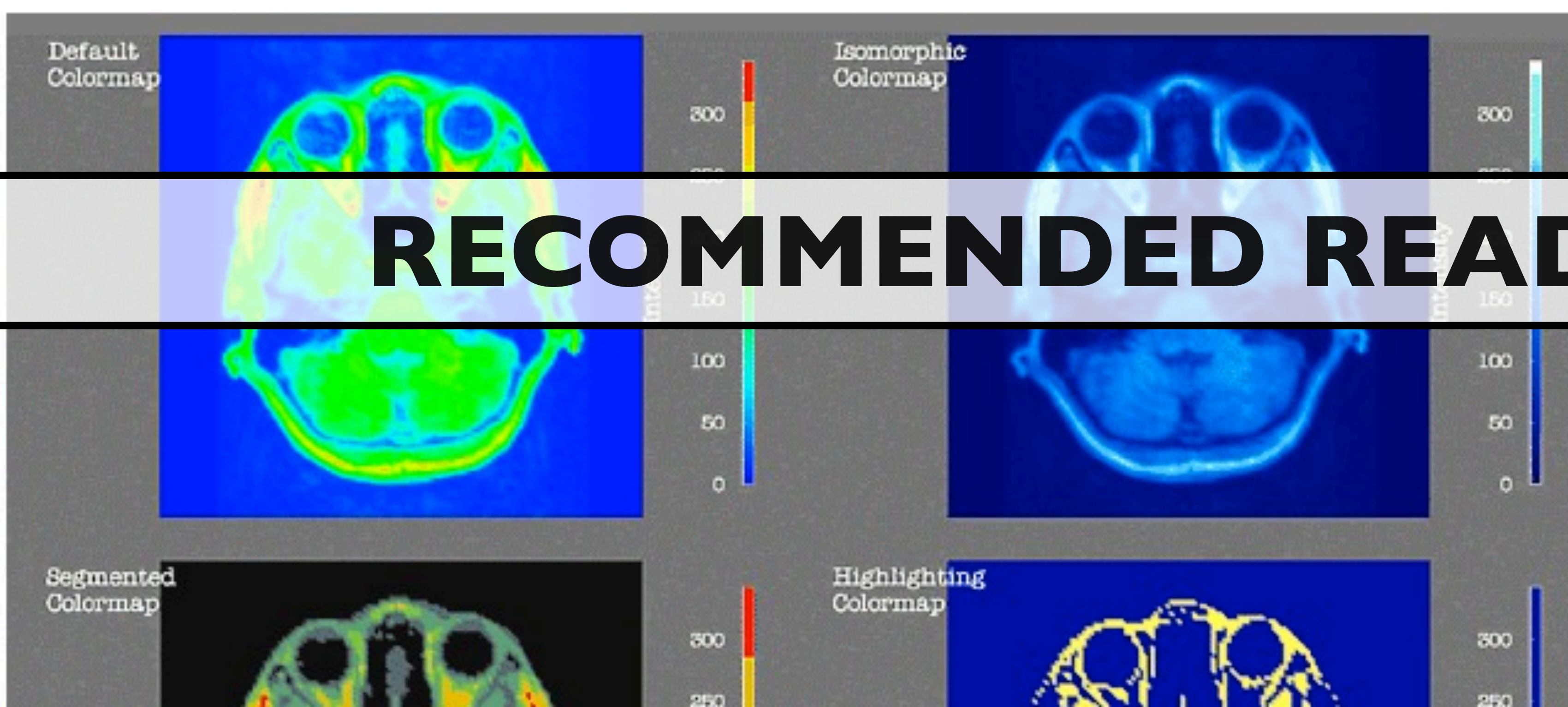
Introduction

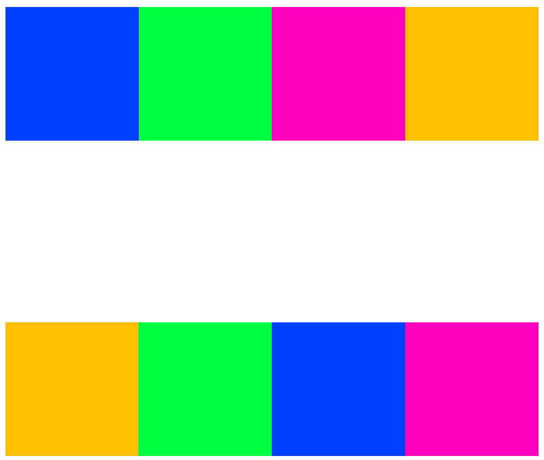
How data are represented visually has a powerful effect on how the structure in those data is perceived. For example, in [Figure 1](), four representations of an MRI scan of a human head are shown. The only difference between these images is the mapping of color to data values, yet, the four representations look very different. Furthermore, the inferences an analyst would draw from these representations would vary considerably. That is, variations in the method of representing the data can significantly influence the user's perception and interpretation of the data.



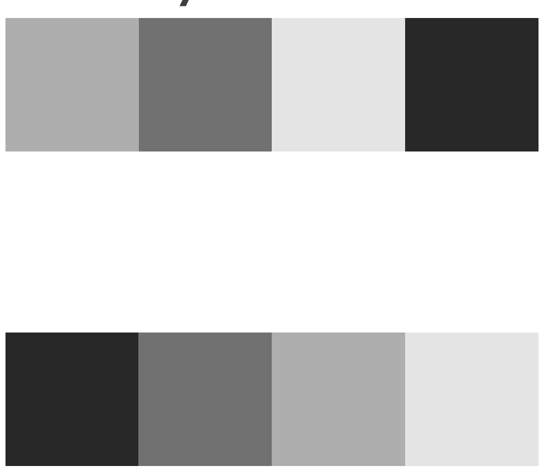
RECOMMENDED READING

rainbow colormaps

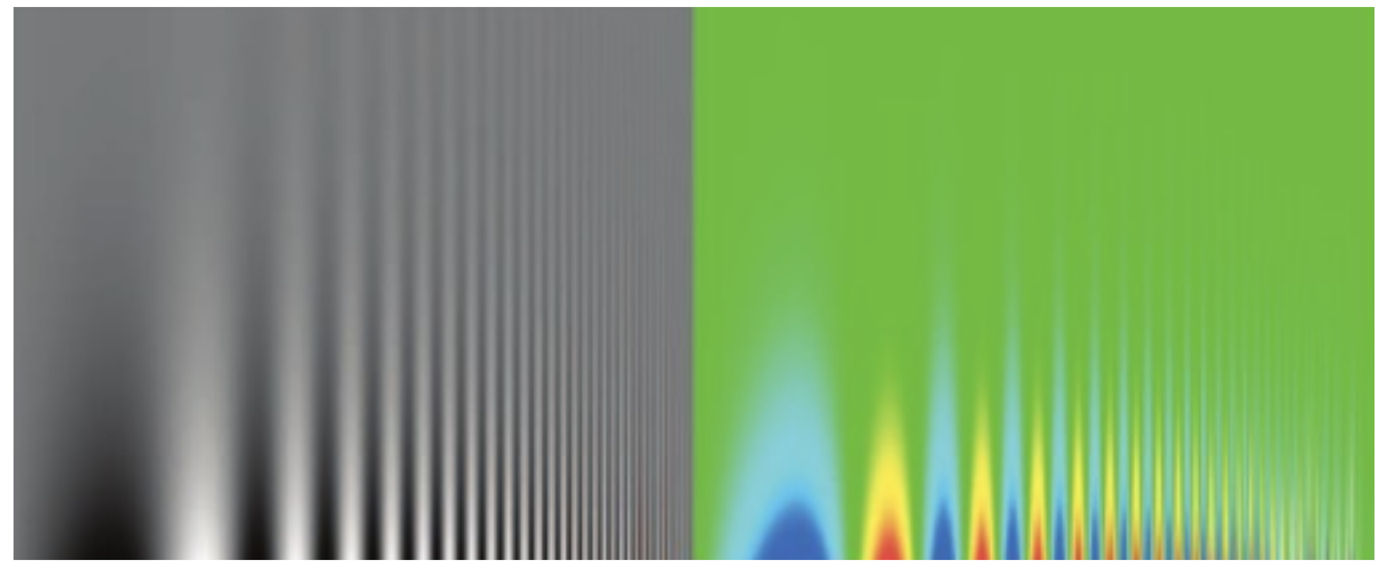
hard to order



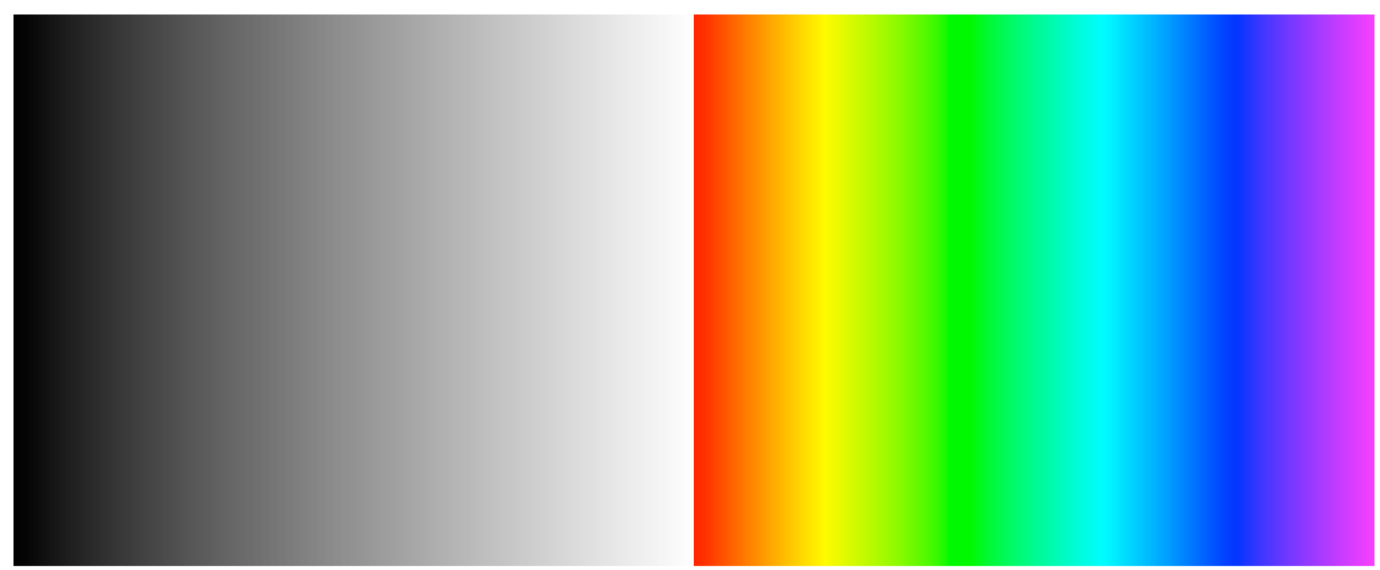
easy to order



lower resolution



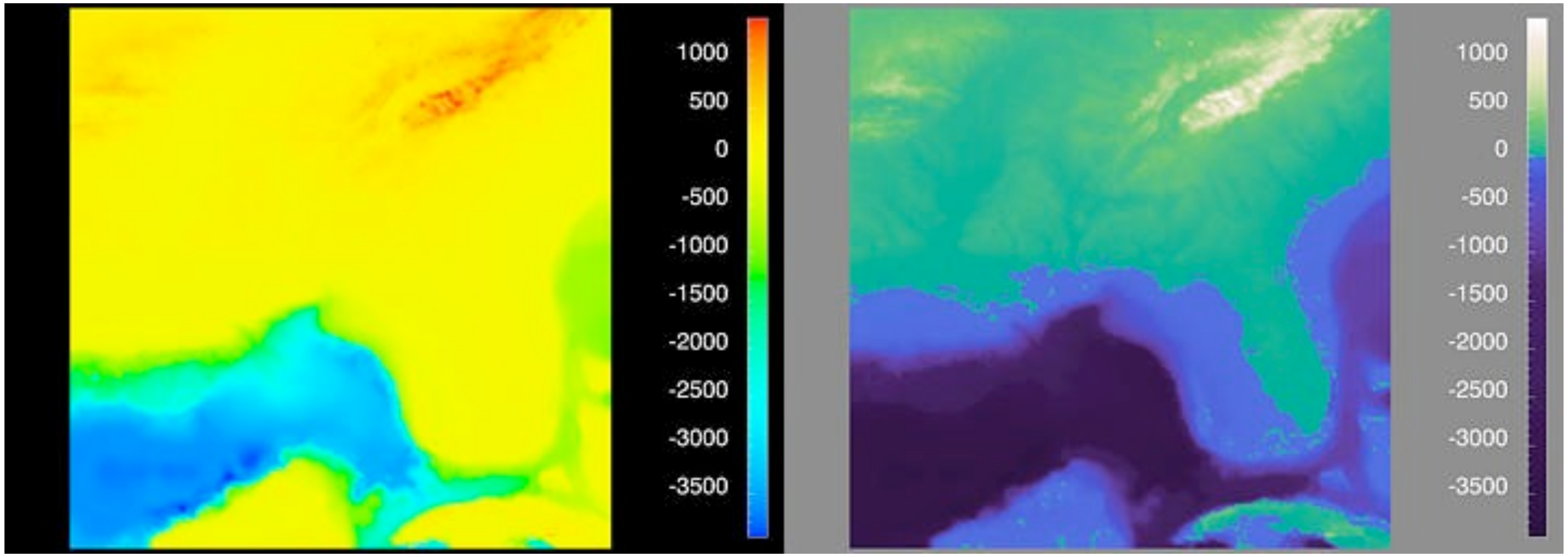
creates artifacts



Borland 2007

rainbow colormaps

Southeastern United States and Gulf of Mexico



zero crossing not explicit

Rogowitz 1996

HELP!

Get it right in black and white.

Maureen Stone

- **hue:** categorical
- **saturation:** ordinal and quantitative
- **luminance:** ordinal and quantitative

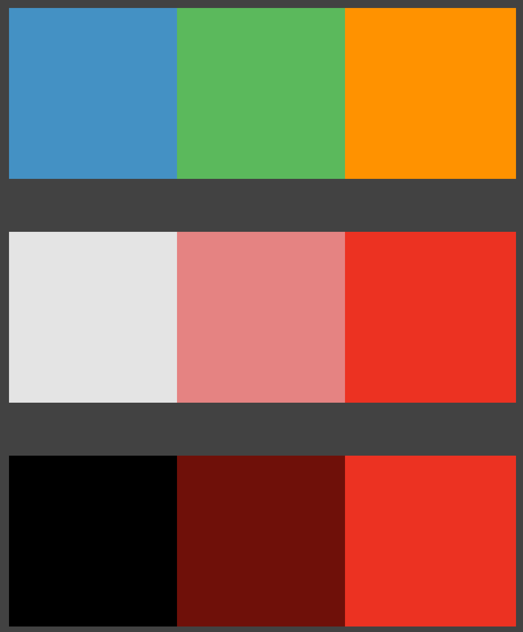
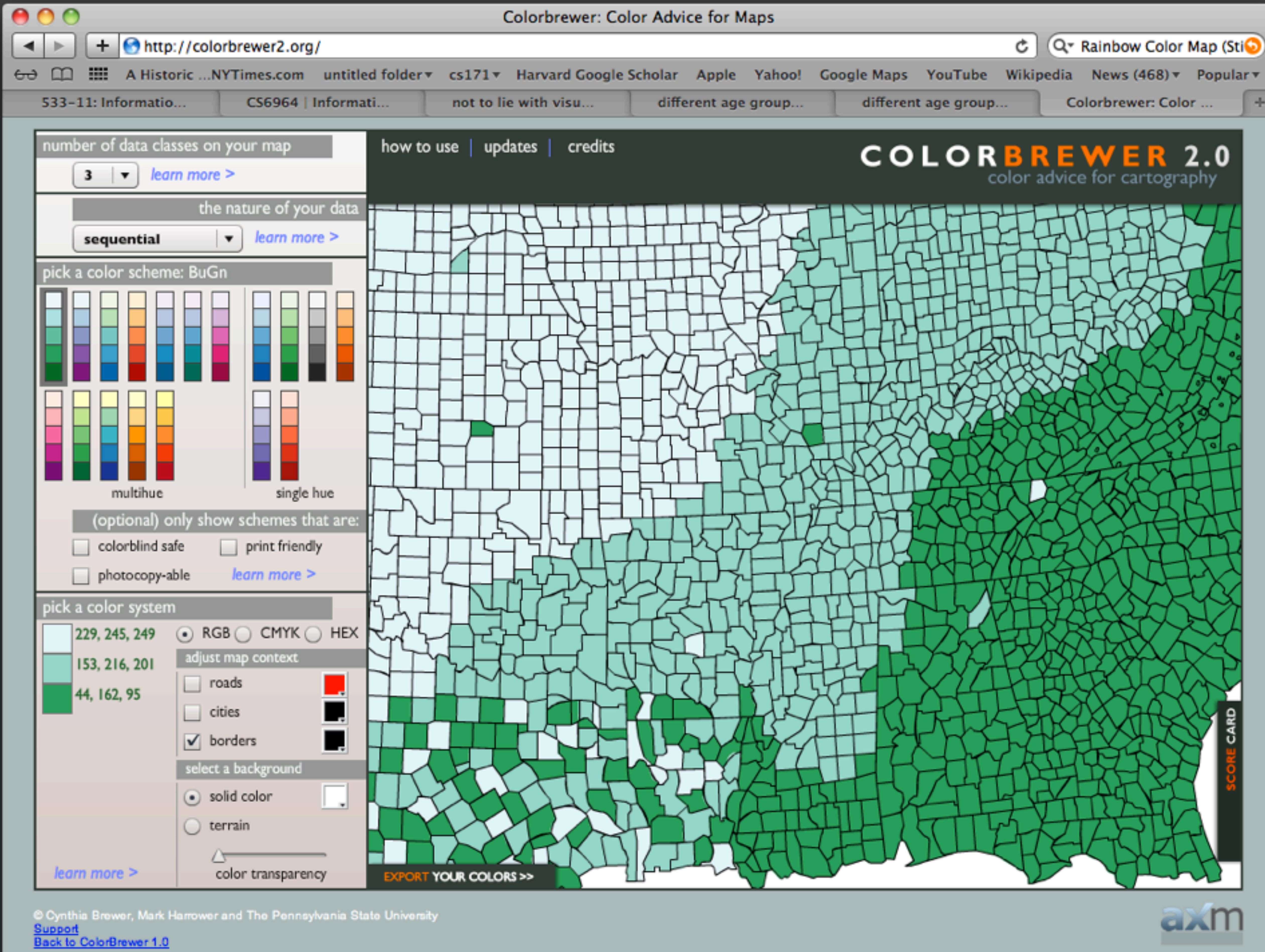
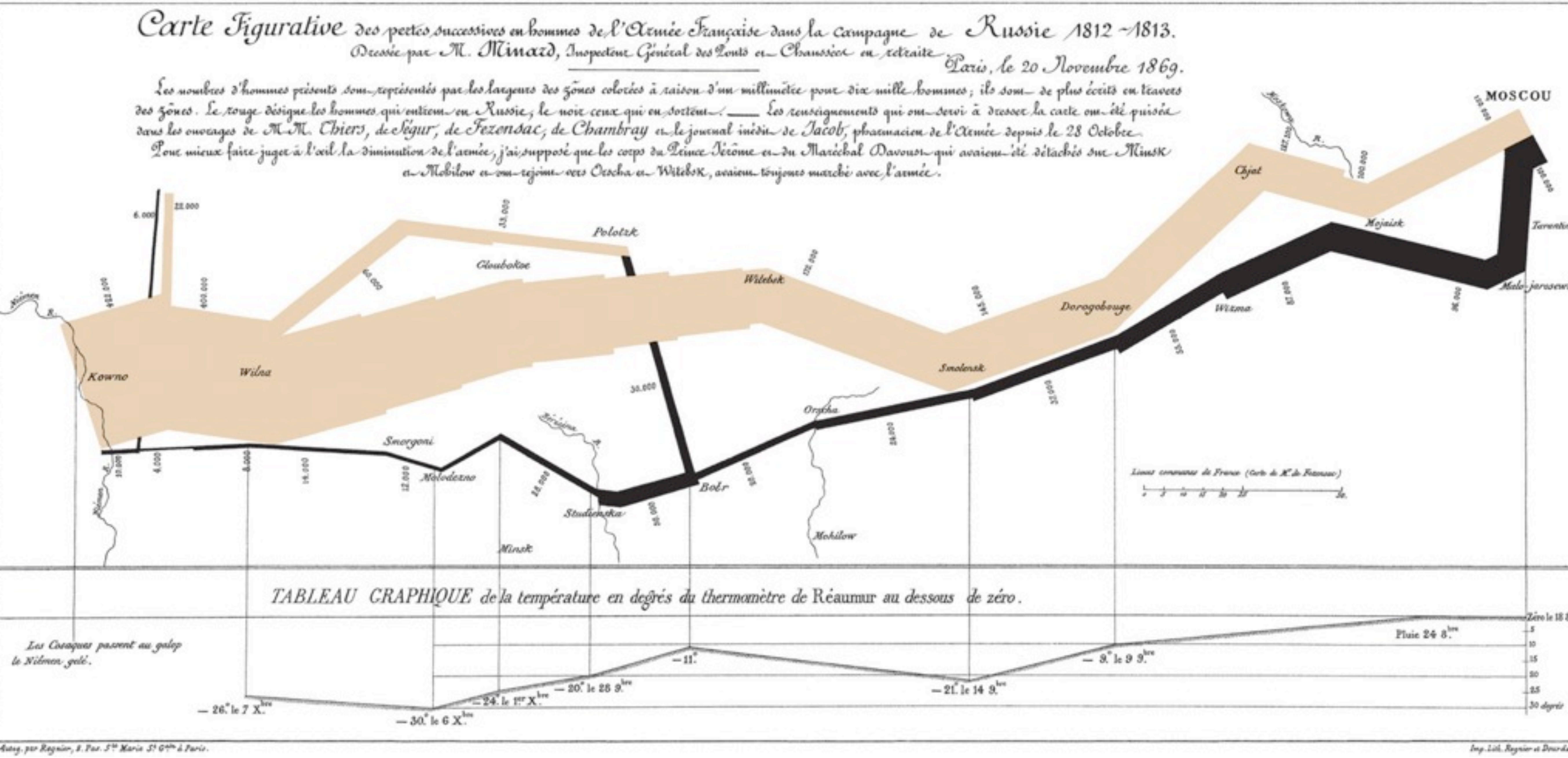


TABLEAU COLORS

http://www.tableausoftware.com/


Colorbrewer: Color Advice for Maps
http://colorbrewer2.org/
Rainbow Color Map (Sti
A Historic ...NYTimes.com
untitled folder
cs171
Harvard Google Scholar
Apple
Yahoo!
Google Maps
YouTube
Wikipedia
News (468)
Popular
533-11: Informatio...
CS6964 | Informati...
not to lie with visu...
different age group...
different age group...
Colorbrewer: Color ...
number of data classes on your map
3
learn more >
the nature of your data
sequential
learn more >
pick a color scheme: BuGn
multihue
single hue
(optional) only show schemes that are:
colorblind safe
print friendly
photocopy-able
learn more >
pick a color system
229, 245, 249
153, 216, 201
44, 162, 95
RGB
CMYK
HEX
adjust map context
roads
cities
borders
select a background
solid color
terrain
color transparency
learn more >
how to use | updates | credits
COLORBREWER 2.0
color advice for cartography
EXPORT YOUR COLORS >>
SCORE CARD
© Cynthia Brewer, Mark Harrower and The Pennsylvania State University
Support
Back to ColorBrewer 1.0

encoding exercise . . .



Carte Figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812–1813.
Dressée par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite.
Paris, le 20 Novembre 1869.
Les nombres d'hommes présents sont représentés par les largeurs des zônes colorées à raison d'un millimètre pour dix mille hommes; ils sont de plus écrits en travers des zônes. Le rouge désigne les hommes qui entrent en Russie, le noir ceux qui en sortent. Les renseignements qui ont servi à dresser la carte ont été puisés dans les ouvrages de M.M. Thiers, de Ségur, de Fezensac, de Chambray et le journal inédit de Jacob, pharmacien de l'Armée depuis le 28 Octobre.
Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supposé que les corps du Prince Jérôme et du Maréchal Davoust qui avaient été détachés sur Minsk et Mobilow et ont rejoint vers Orscha et Witebsk, avaient toujours marché avec l'armée.
MOSCOU
Kowno
Wilna
Polotzk
Gloubokoe
Witebsk
Smolensk
Dorogobouge
Chjat
Mojaisk
Tarantino
Malo-jarosewli
Wizma
Orscha
Smorgoni
Molodezno
Studienska
Bobr
Minsk
Mobilow
TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.
Les Cosaques passent au galop le Niémen gelé.
Zéro le 18 8bre
Pluie 24 8bre
— 9° le 9 9bre
— 11°
— 21° le 14 9bre
— 20° le 28 9bre
— 24° le 1er Xbre
— 30° le 6 Xbre
— 26° le 7 Xbre
30 degrés

Minard 1869

L6: Tasks and Interaction

REQUIRED READING

4

Interaction Principles

Several principles of interaction are important when designing a visualization: classes of change, latency and feedback, the costs of interactivity, and spatial cognition. Two slogans summarize sets of tradeoffs: one is *eyes over memory*, and another is *resolution and integration over immersion*.

4.1 Classes of Change

The fundamental point of interactivity is that the display is dynamic rather than static; that is, things change. We can categorize the kind of change that occurs in a display into four major types: a change of selection that triggers a different highlighting of dataset elements, a change of viewport that arises from navigating, a change of spatial ordering of the elements from sorting, and a change of the entire visual encoding.

4.1.1 Changing Selection

Selecting items is a fundamental piece of the interaction vocabulary. Many other higher-level interactions are handled as operations that affect the

The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations

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Abstract: A useful starting point for designing advanced graphical user interfaces is the Visual Information-Seeking Mantra: Overview first, zoom and filter, then details-on-demand. But this is only a starting point in trying to understand the rich and varied set of information visualizations that have been proposed in recent years. This paper offers a task by data type taxonomy with seven data types (1-, 2-, 3-dimensional data, temporal and multi-dimensional data, and tree and network data) and seven tasks (overview, zoom, filter, details-on-demand, relate, history, and extract).

Everything points to the conclusion that the phrase 'the language of art' is more than a loose metaphor, that even to describe the visible world in images we need a developed system of schemata.

E. H. Gombrich *Art and Illusion,* 1959 (p. 76)

1. Introduction

Information exploration should be a joyous

understood information need (known-item search) to developing an understanding of unexpected patterns within the collection (browse) (Marchionini, 1995).

Exploring information collections becomes increasingly difficult as the volume grows. A page of information is easy to explore, but when the information becomes the size of a book, or library, or even larger, it may be difficult to locate known items or to browse to gain an overview.

Designers are just discovering how to use the rapid and high resolution color displays to present large amounts of information in orderly and user-controlled ways. Perceptual psychologists, statisticians, and graphic designers (Bertin, 1983; Cleveland, 1993; Tufte, 1983, 1990) offer valuable guidance about presenting static information, but the opportunity for dynamic displays takes user interface designers well beyond current wisdom.

2. Visual Information Seeking Mantra

The success of direct-manipulation interfaces is indicative of the power of using computers in a more visual or graphic manner. A picture is often cited to be worth a thousand words and, for some (but not all)

Low-Level Components of Analytic Activity in Information Visualization

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College of Computing/GVU Center
Georgia Institute of Technology

ABSTRACT

Existing system-level taxonomies of visualization tasks are geared more towards the design of particular representations than the facilitation of user analytic activity. We present a set of ten low-level analysis tasks that largely capture people's activities while employing information visualization tools for understanding data. To help develop these tasks, we collected nearly 200 sample questions from students about how they would analyze five particular data sets from different domains. The questions, while not being totally comprehensive, illustrated the sheer variety of analytic questions typically posed by users when employing information visualization systems. We hope that the presented set of tasks is useful for information visualization system designers as a kind of common substrate to discuss the relative analytic capabilities of the systems. Further, the tasks may provide a form of checklist for system designers.

CR Categories and Subject Descriptors: H.5.0 [Information Interfaces and Presentation]: General; J.0 [Computer Applications]: General

Additional Keywords: Analytic activity, taxonomy, knowledge discovery, design, evaluation.

1 INTRODUCTION

Information visualization research, especially that dealing with the automatic generation of information presentations [10,15], has produced several taxonomies of system tasks that map visualization operations to user cognitive processes. In one sense, these taxonomies might be considered low-level task taxonomies

With the aim of generating an actionable means for supporting analytic activity, we wish to rethink some of the lower-level task taxonomies that focus on a generated presentation as an end result. In general, information visualization can benefit from understanding the tasks that users accomplish while doing actual analytic activity. Such understanding achieves two goals: first, it aids designers in creating novel presentations that amplify users' analytic abilities; second, it provides a common vocabulary for evaluating the abilities and affordances of information visualization systems with respect to user tasks.

We argue that a stronger focus on user tasks and analytic activities in information visualization is necessary as current tools do not seem to support analytic activity consistently. A 2004 study by Saraiya and North found that insights generated from tools used to visualize gene expression data were not generally valuable according to domain experts [11]. Systems such as IN-SPIRE [7] support analytic activities within the domain of document search but may not generalize across domains. Current tools may not even support representational activity very well; consider, for example, the Kobsa study showing only 68-75% accuracy on relatively simple tasks during commercial tool evaluation [8].

1.2 The Nature of Analytic Activity

User analysis questions and tasks as part of analytic activity typically range from broader, "high-level" goals to much more specific, "low-level" inquiries. For example, a person studying the history of motion picture films may have "high-level", uncertainty-tinged knowledge goals such as understanding trends in popularity over time or determining how to predict which