Data Visualization Principles: Other Perceptual Channels

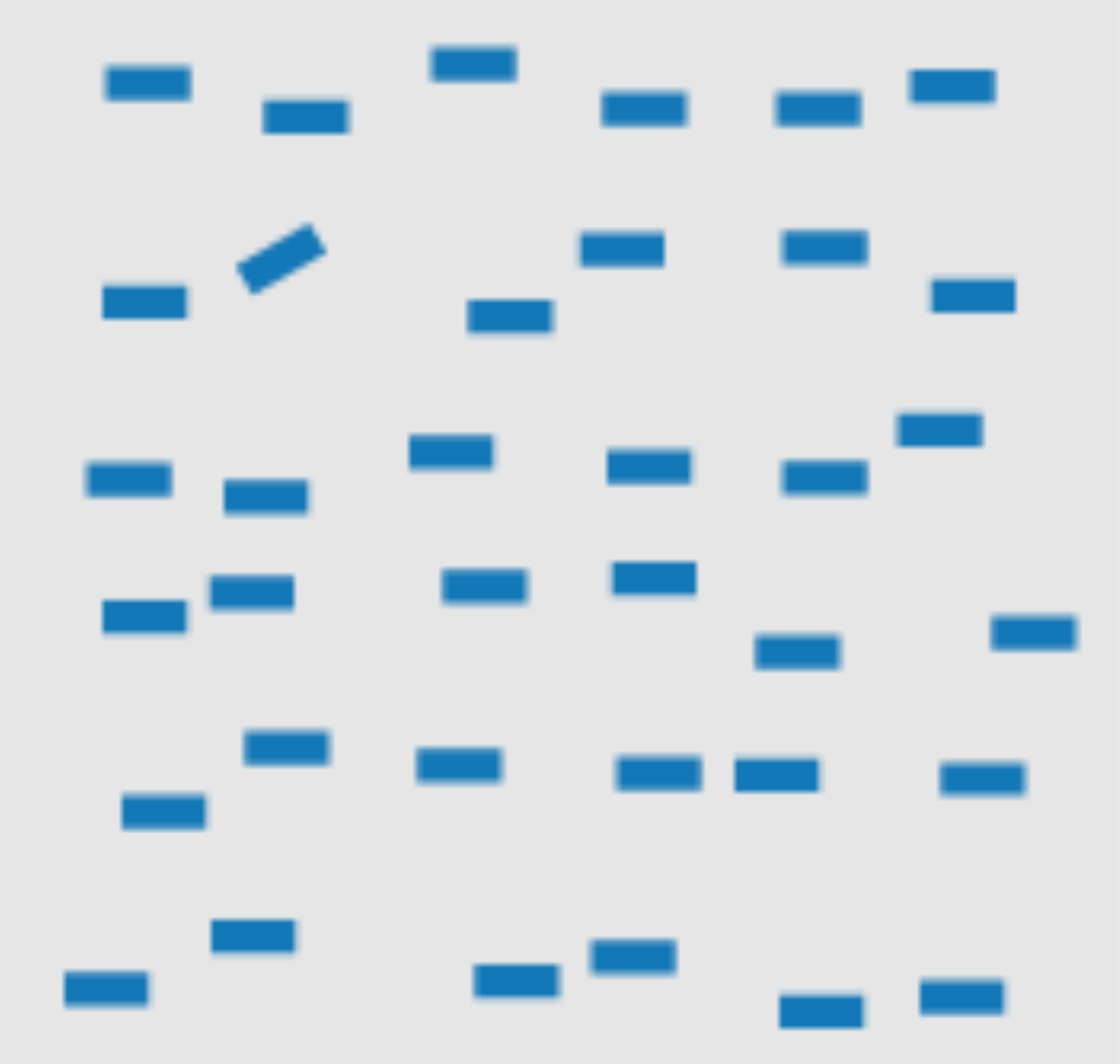
CSC444

Acknowledgments for today's lecture:
Tamara Munzner, Miriah Meyer, Colin Ware, Christopher Healey

PREATTENTIVENESS,

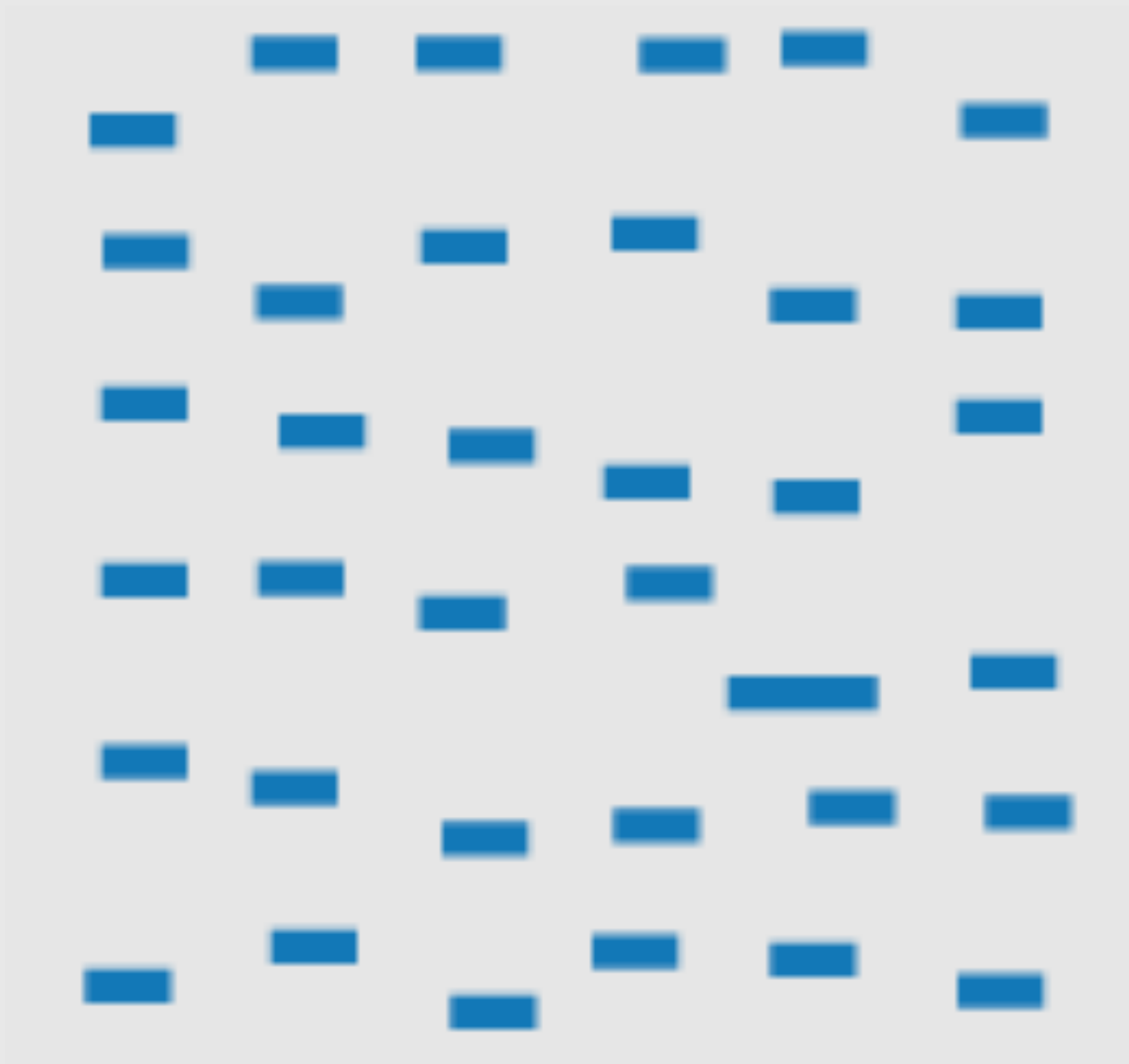
OR “VISUAL POP-OUT”

ORIENTATION



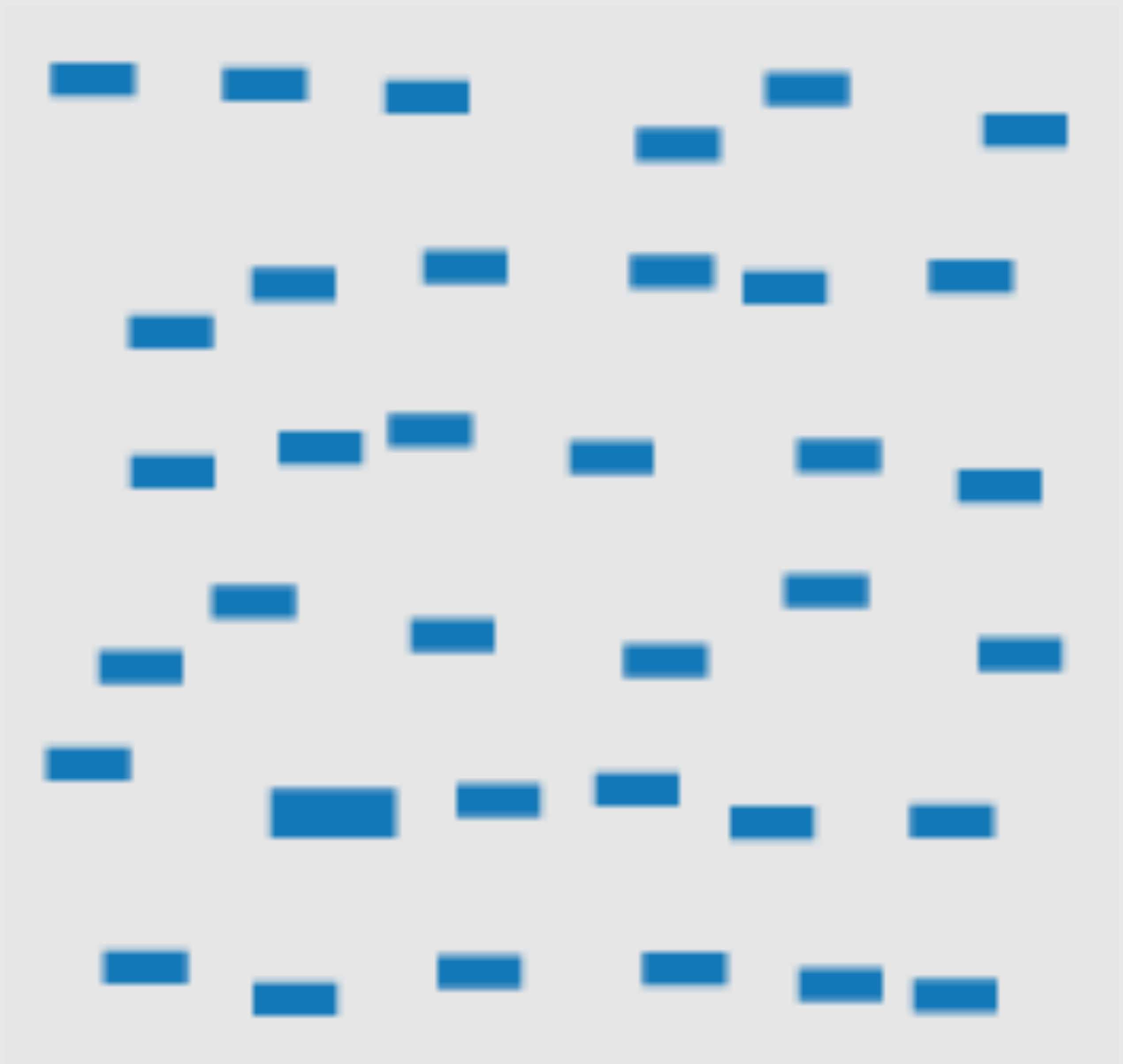
Christopher Healey, http://www.csc.ncsu.edu/faculty/healey/PP/index.html

WIDTH/LENGTH

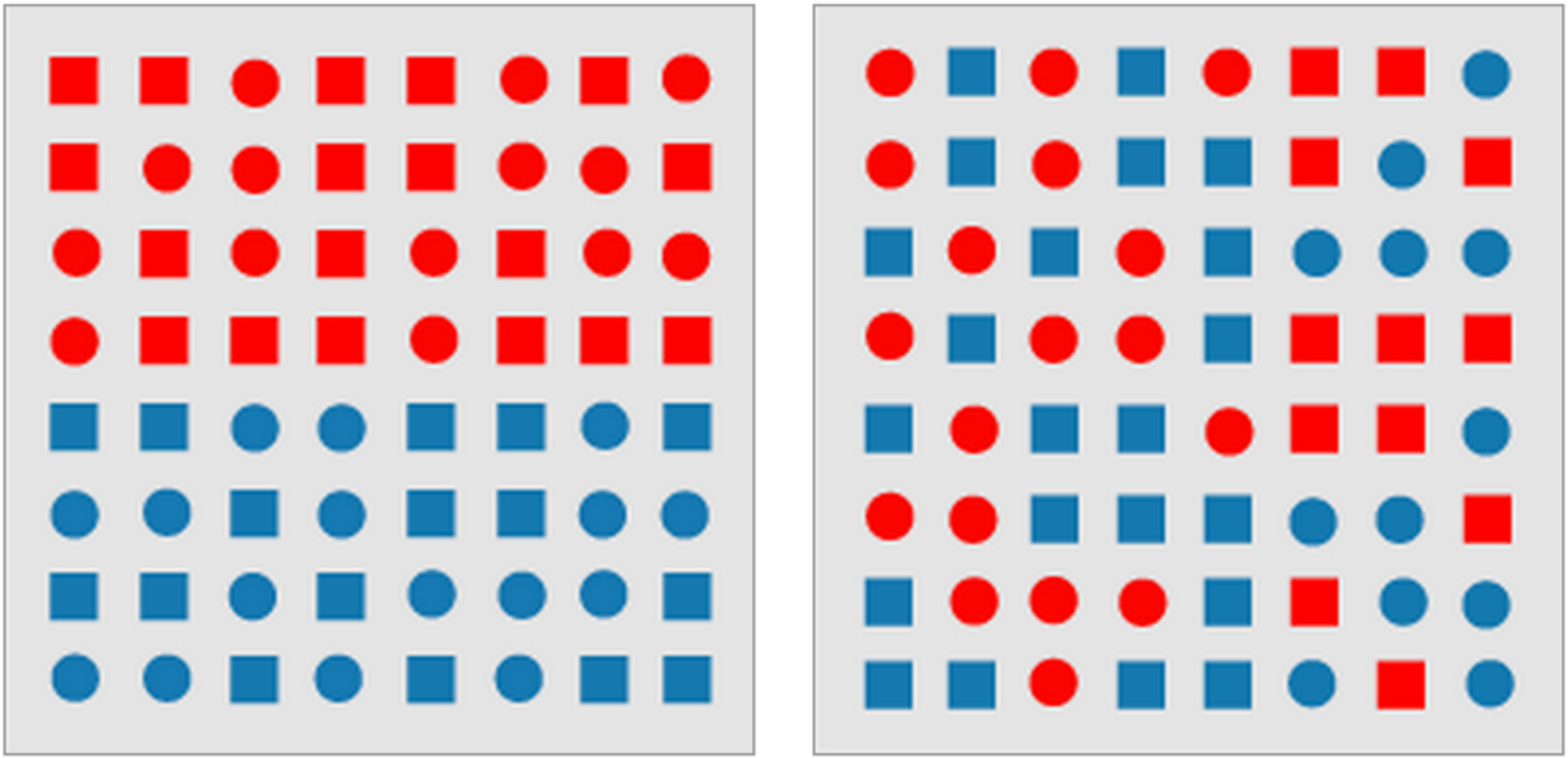


Christopher Healey, http://www.csc.ncsu.edu/faculty/healey/PP/index.html

SIZE

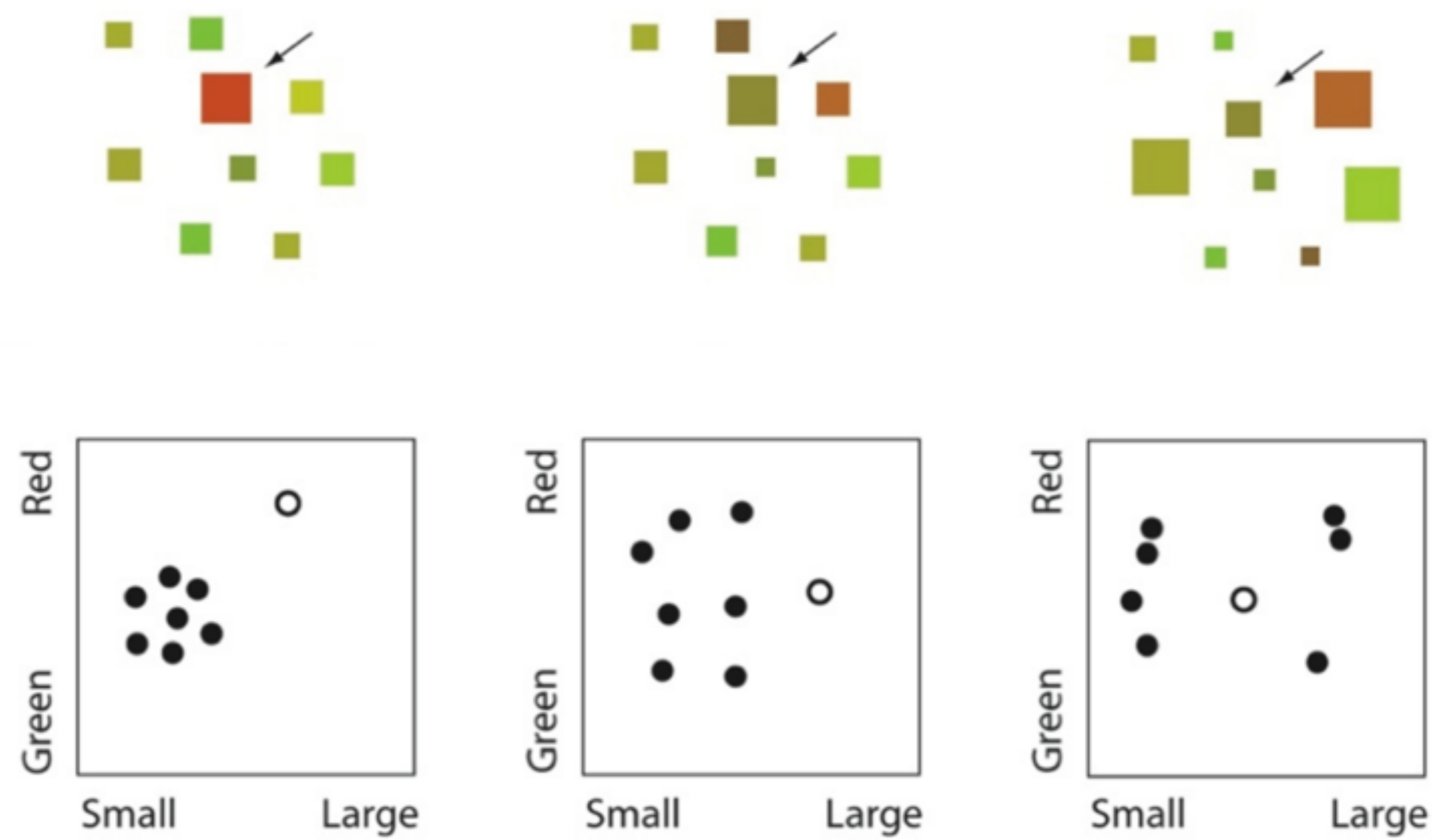


Christopher Healey, http://www.csc.ncsu.edu/faculty/healey/PP/index.html



(a) (b)

Mixing is not always pre-attentive



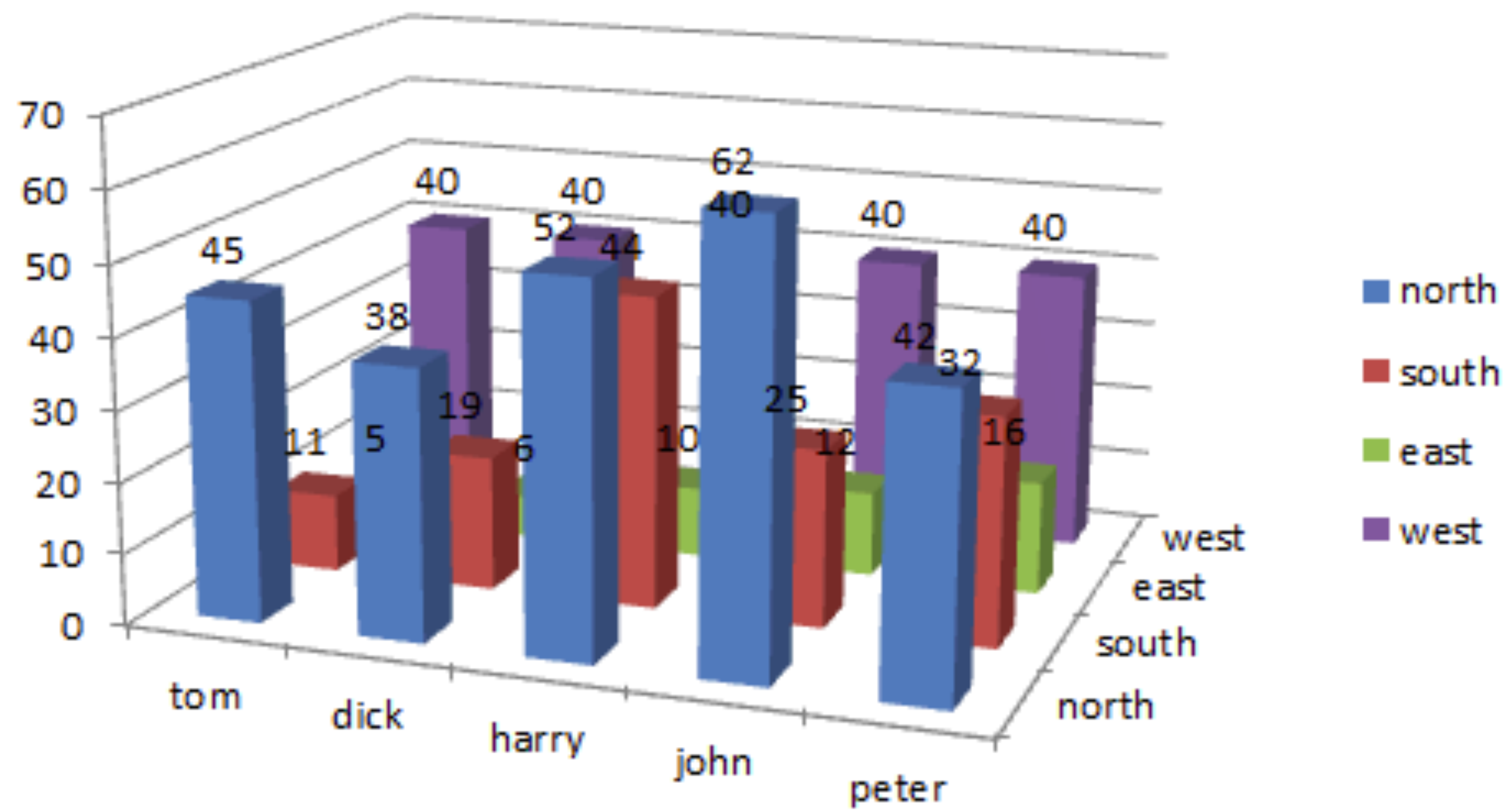
Preattentiveness is only simple one-channel-at-a-time.

VISUAL CHANNELS YOU SHOULD BE CAREFUL WITH, EVEN IN ISOLATION

3D, when data isn't

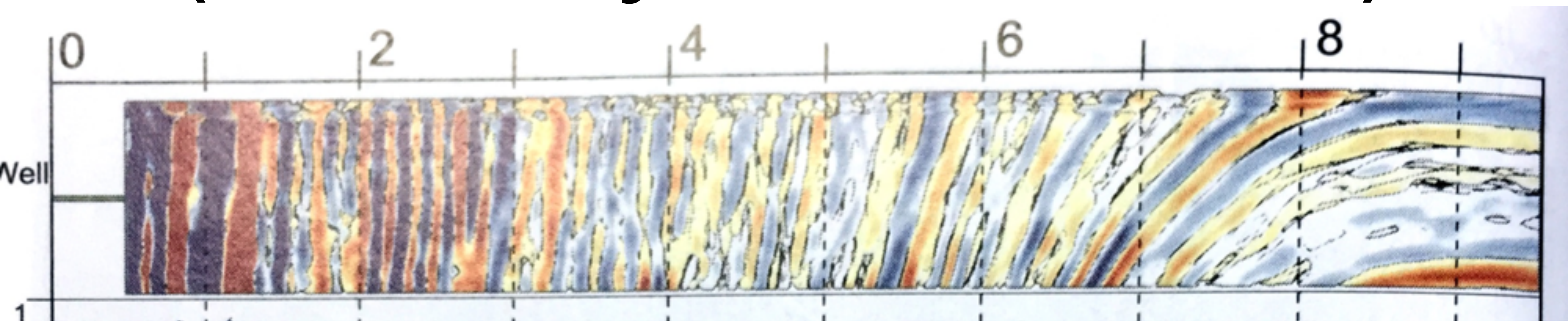
- Perspective interacts with size and color judgments

- Occlusion is bad, often unnecessary



Naomi Robbins, forbes.com

(and maybe even it is!)



Daae Lampe et al. TVCG 2009

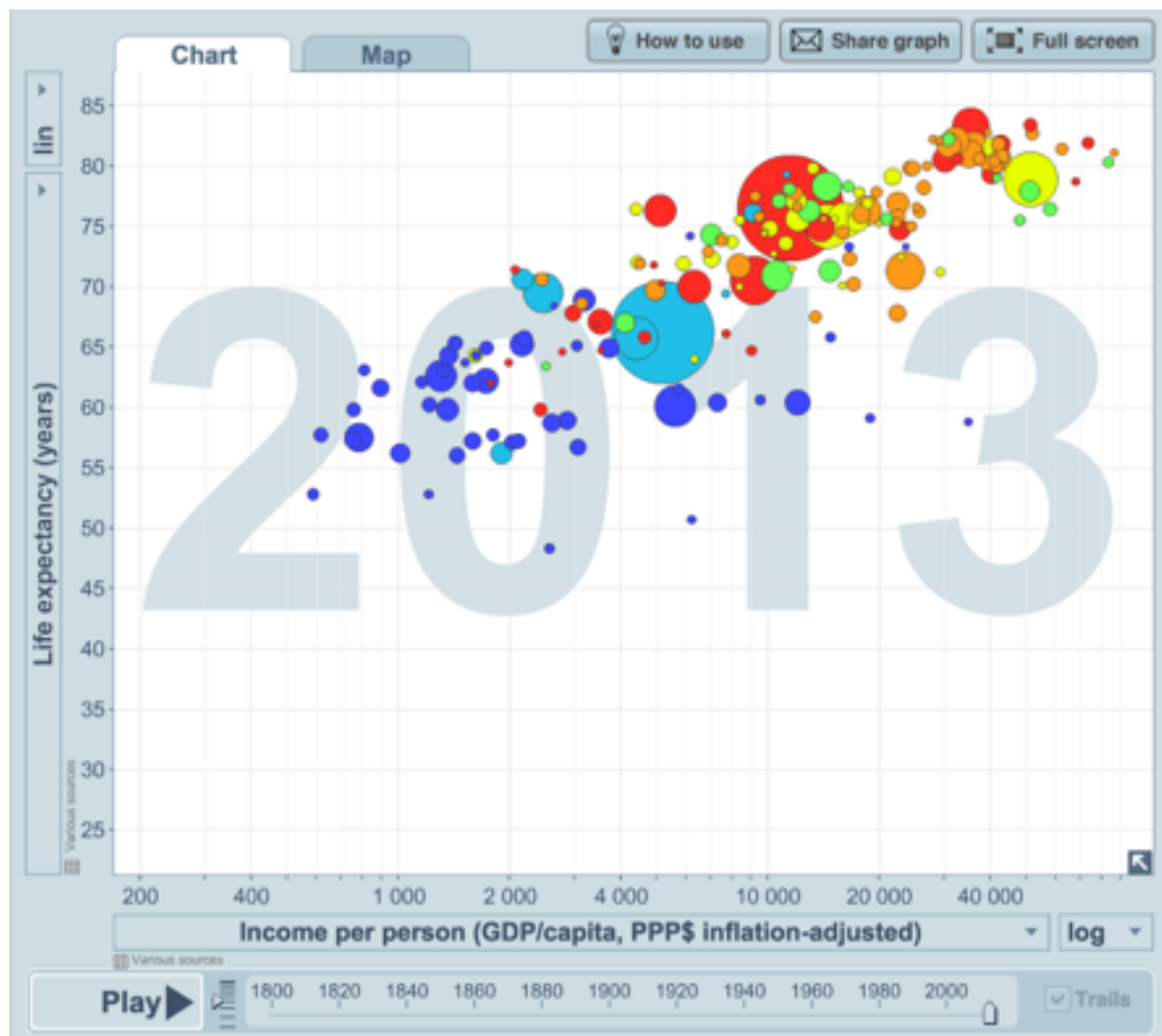
Animations

- We perceive motion, and regularity, even when none might be intended

- http://en.wikipedia.org/wiki/File:Lilac-Chaser.gif
  - And it interacts badly with the rest of our perceptual system

Animations

- avoid them, except for data transitions preferably controlled by interaction



www.gapminder.org

- **Recommended reading for CS544 students**

Animated Transitions in Statistical Data Graphics

Jeffrey Heer, George G. Robertson

Abstract—In this paper we investigate the effectiveness of animated transitions between common statistical data graphics such as bar charts, pie charts, and scatter plots. We extend theoretical models of data graphics to include such transitions, introducing a taxonomy of transition types. We then propose design principles for creating effective transitions and illustrate the application of these principles in *DynaVis*, a visualization system featuring animated data graphics. Two controlled experiments were conducted to assess the efficacy of various transition types, finding that animated transitions can significantly improve graphical perception.

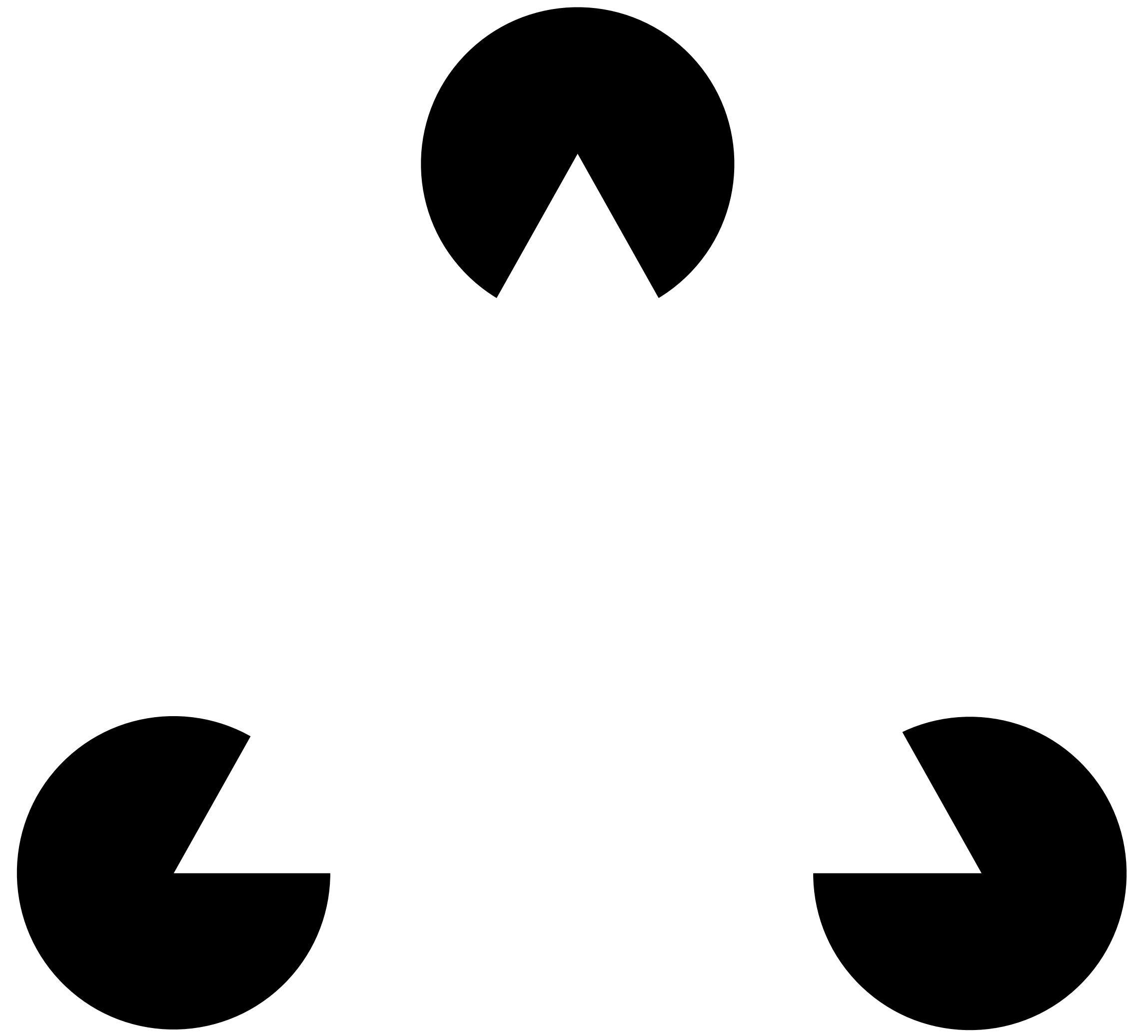
Index Terms—Statistical data graphics, animation, transitions, information visualization, design, experiment

1 Introduction

In both analysis and presentation, it is common to view a number of related data graphics backed by a shared data set. For example, a business analyst viewing a bar chart of product sales may want to view relative percentages by switching to a pie chart or compare sales with profits in a scatter plot. Similarly, she may wish to see product sales by region, drilling down from a bar chart to a grouped bar chart. Such incremental construction of visualizations is regularly performed in tools such as Excel, Tableau, and Spotfire.

The visualization challenge posed by each of these examples is to keep the readers of data graphics oriented during transitions. Ideally, viewers would accurately identify elements across disparate graphics and understand the relationship between the current and previous applied to direct attention to points of interest. Second, animation facilitates object constancy for changing objects [17, 20], including changes of position, size, shape, and color, and thus provides a natural way of conveying transformations of an object. Third, animated behaviors can give rise to perceptions of causality and intentionality [16], communicating cause-and-effect relationships and establishing narrative. Fourth, animation can be emotionally engaging [24, 25], engendering increased interest or enjoyment.

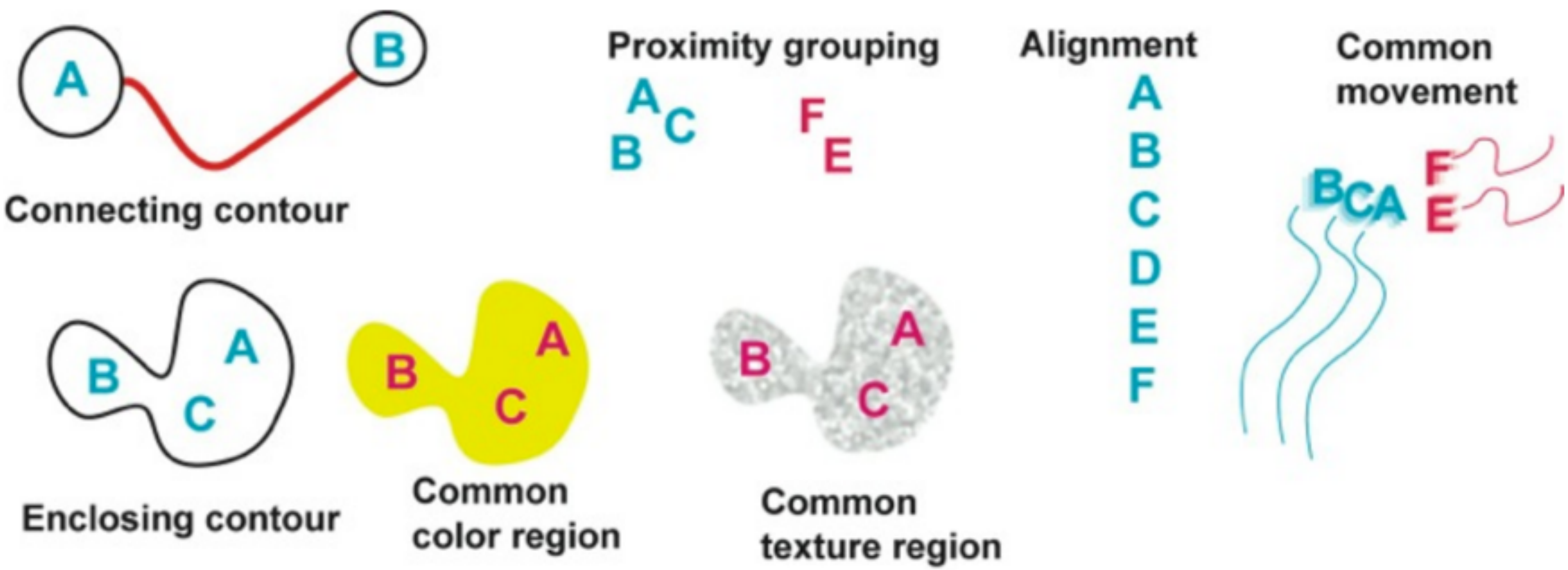
However, each of the above features can prove more harmful than helpful. Animation's ability to grab attention can be a powerful force for distraction. Object constancy can be abused if an object is transformed into a completely unrelated object, establishing a false



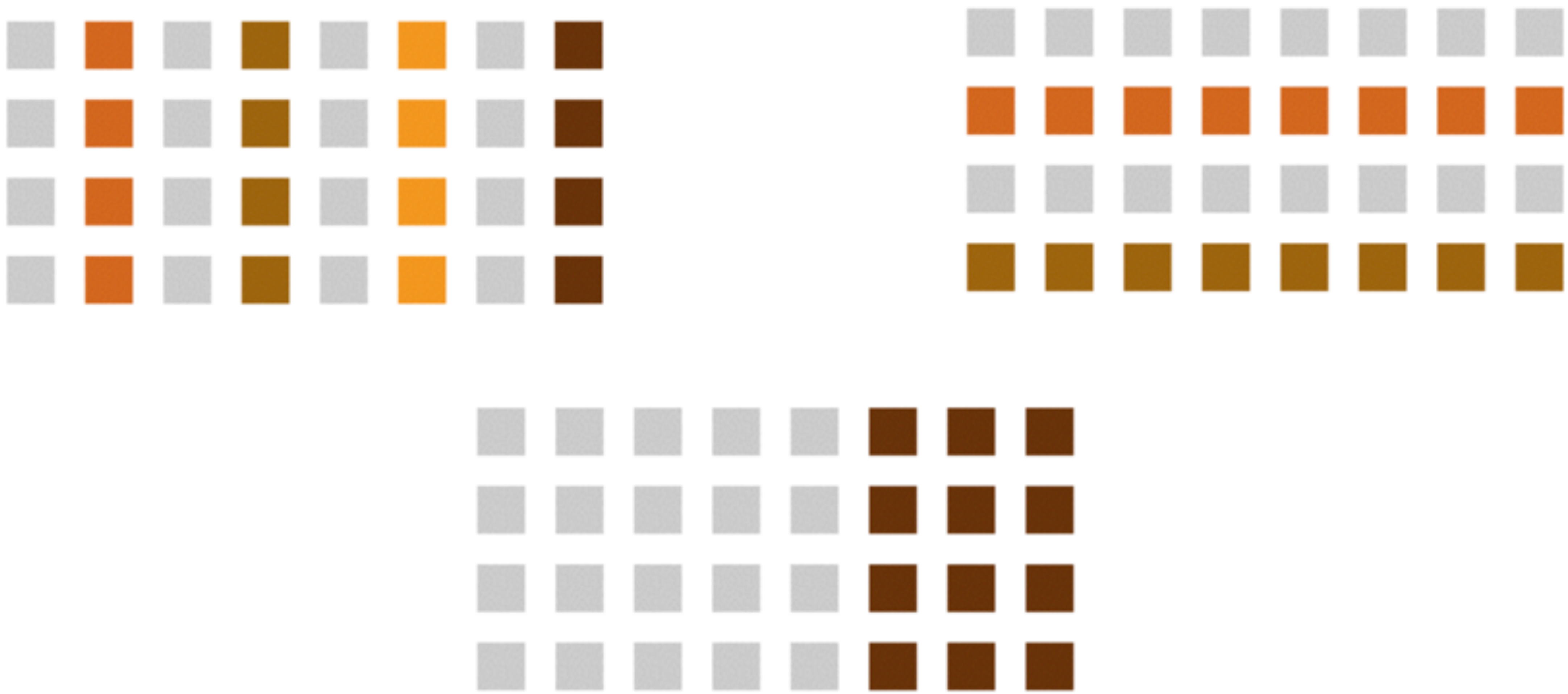
GESTALT PRINCIPLES

GESTALT PRINCIPLES

- General idea: we interpret stimuli as patterns that are grouped, complete, whole
    - Even when they aren't



GESTALT: SIMILARITY



We use color to connect things into groups

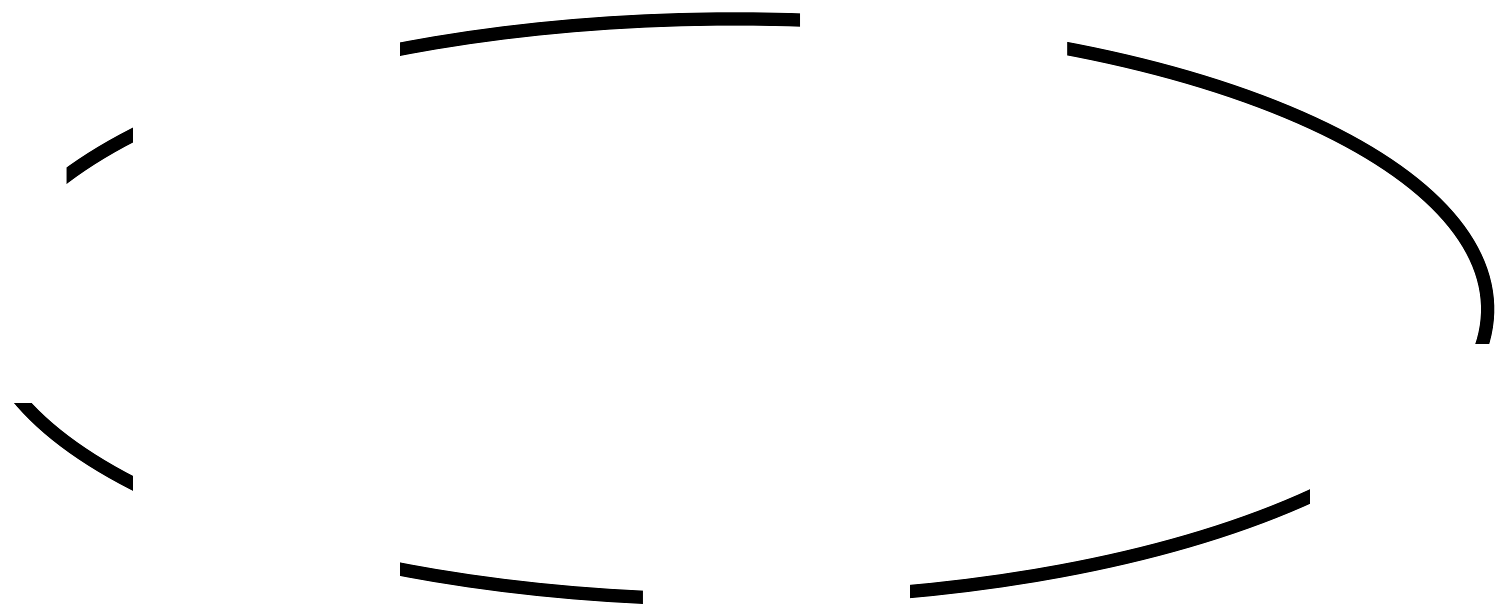
http://www.andyrutledge.com/gestalt-principles-1-figure-ground-relationship.php

GESTALT: PROXIMITY

We use distance to connect things into groups

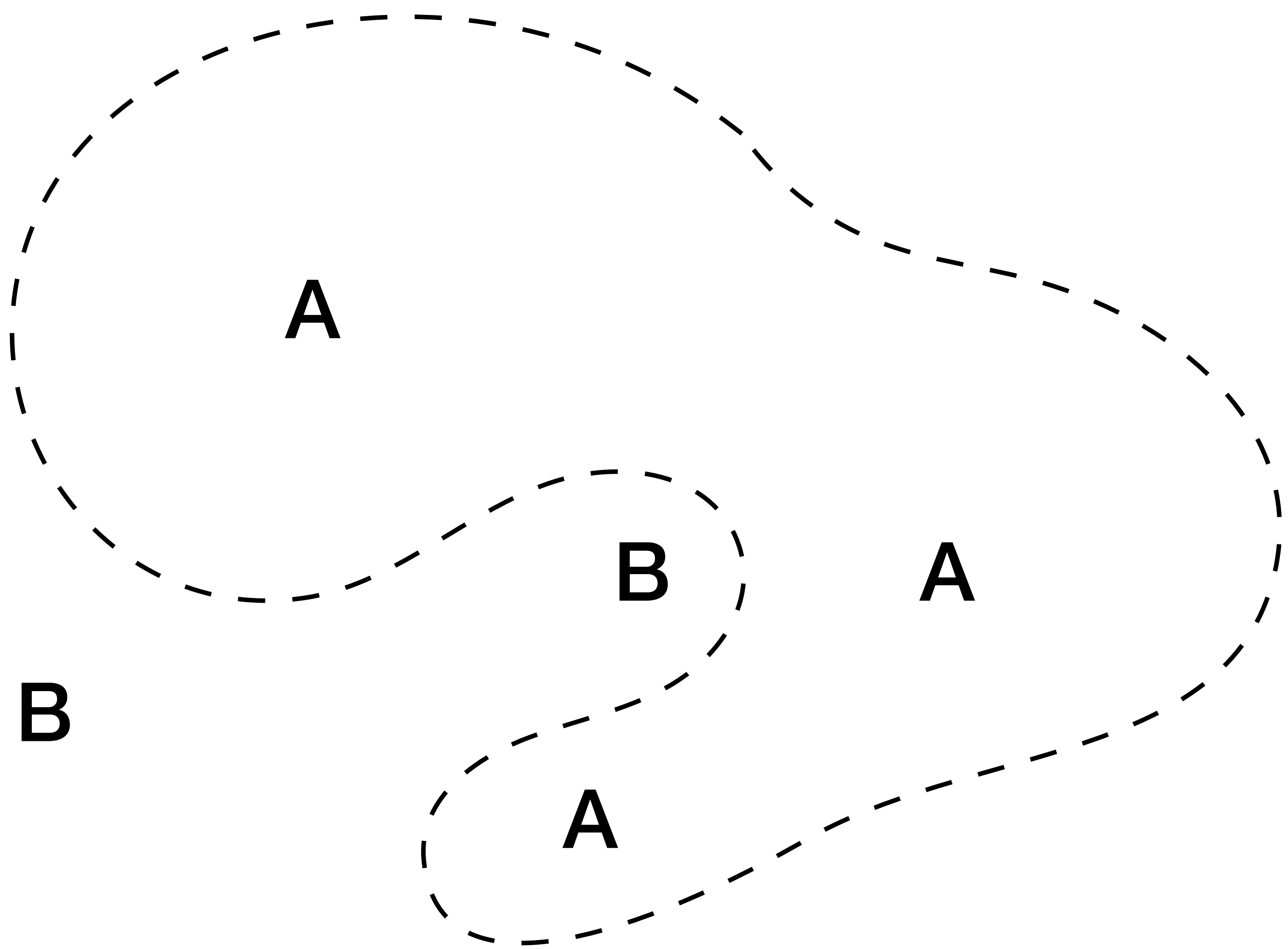
http://www.andyrutledge.com/gestalt-principles-1-figure-ground-relationship.php

GESTALT: CLOSURE



We see closed shapes, even when they’re not there

GESTALT: CONTAINMENT



Objects inside closed shapes appear related, even when they're far apart

GESTALT: CONTAINMENT

IEEE TRANSACTIONS ON VISUALIZATION AND COMPUTER GRAPHICS, VOL. 15, NO. 6, NOVEMBER/DECEMBER 2009 1009

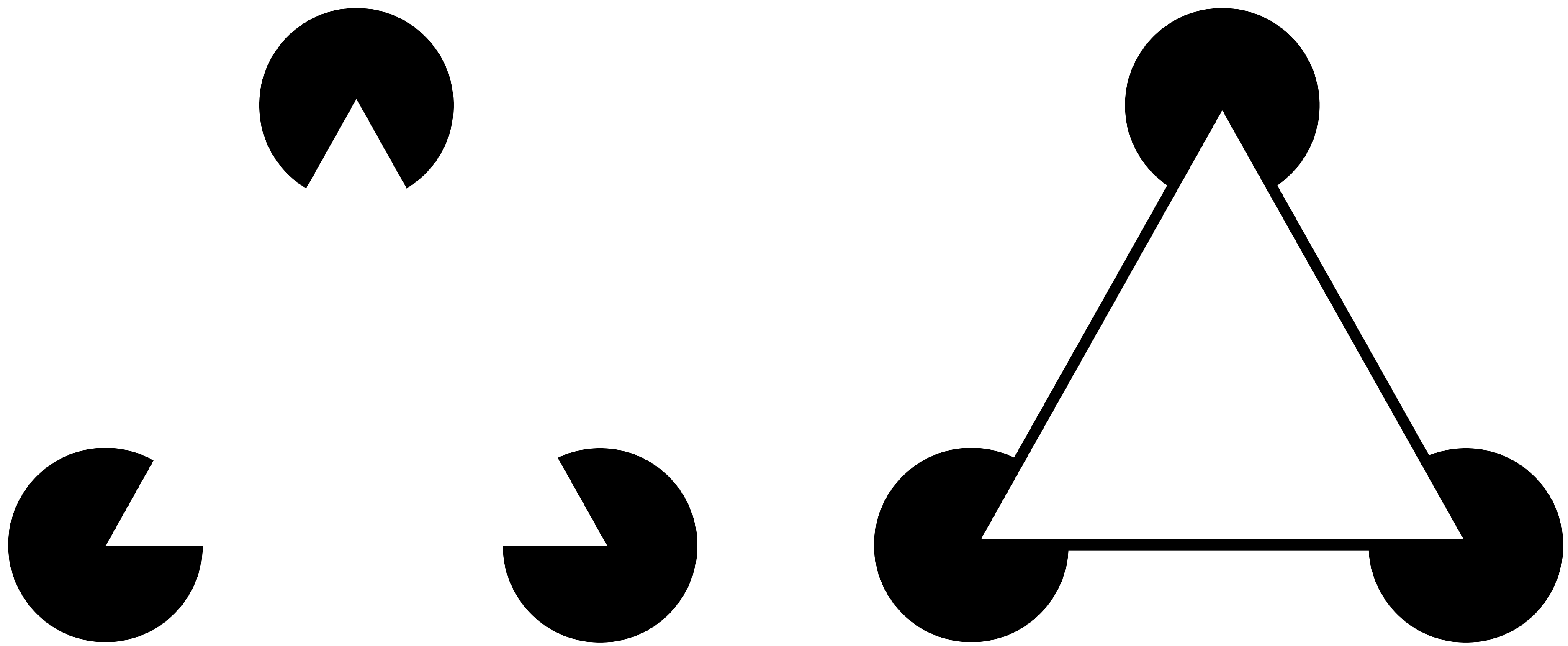
Bubble Sets: Revealing Set Relations with Isocontours over Existing Visualizations

Christopher Collins, Gerald Penn, and Sheelagh Carpendale

Abstract—While many data sets contain multiple relationships, depicting more than one data relationship within a single visualization is challenging. We introduce Bubble Sets as a visualization technique for data that has both a primary data relation with a semantically significant spatial organization and a significant set membership relation in which members of the same set are not necessarily adjacent in the primary layout. In order to maintain the spatial rights of the primary data relation, we avoid layout adjustment techniques that improve set cluster continuity and density. Instead, we use a continuous, possibly concave, isocontour to delineate set membership, without disrupting the primary layout. Optimizations minimize cluster overlap and provide for calculation of the isocontours at interactive speeds. Case studies show how this technique can be used to indicate multiple sets on a variety of common visualizations.

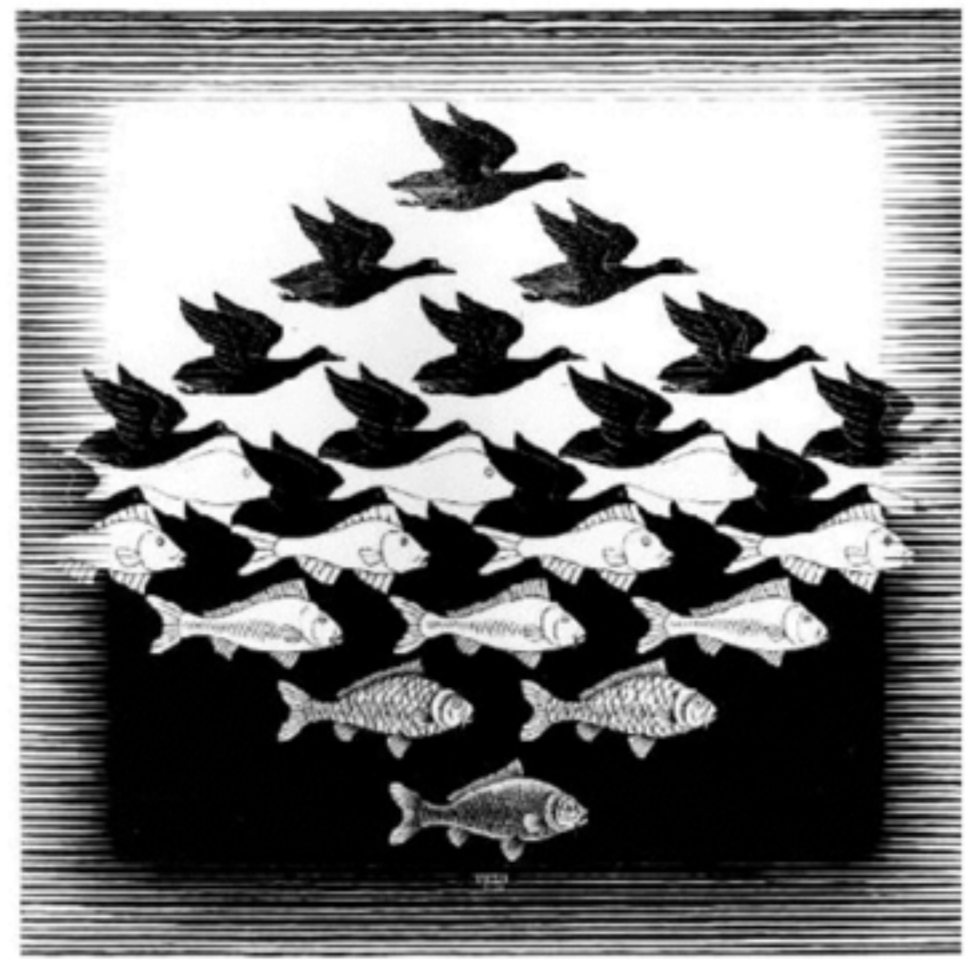
Index Terms—clustering, spatial layout, graph visualization, tree visualization.

GESTALT: CONTINUITY



We see simple, connected figure/ground shapes rather than complicated shapes

GESTALT: FIGURE/GROUND



M.C. Escher: *Sky and Water I* 1938 woodcut

We see simple, connected figure/ground shapes rather than complicated shapes

HIGHER-LEVEL CHANNELS WE ARE STILL STUDYING

Overlays for bivariate maps

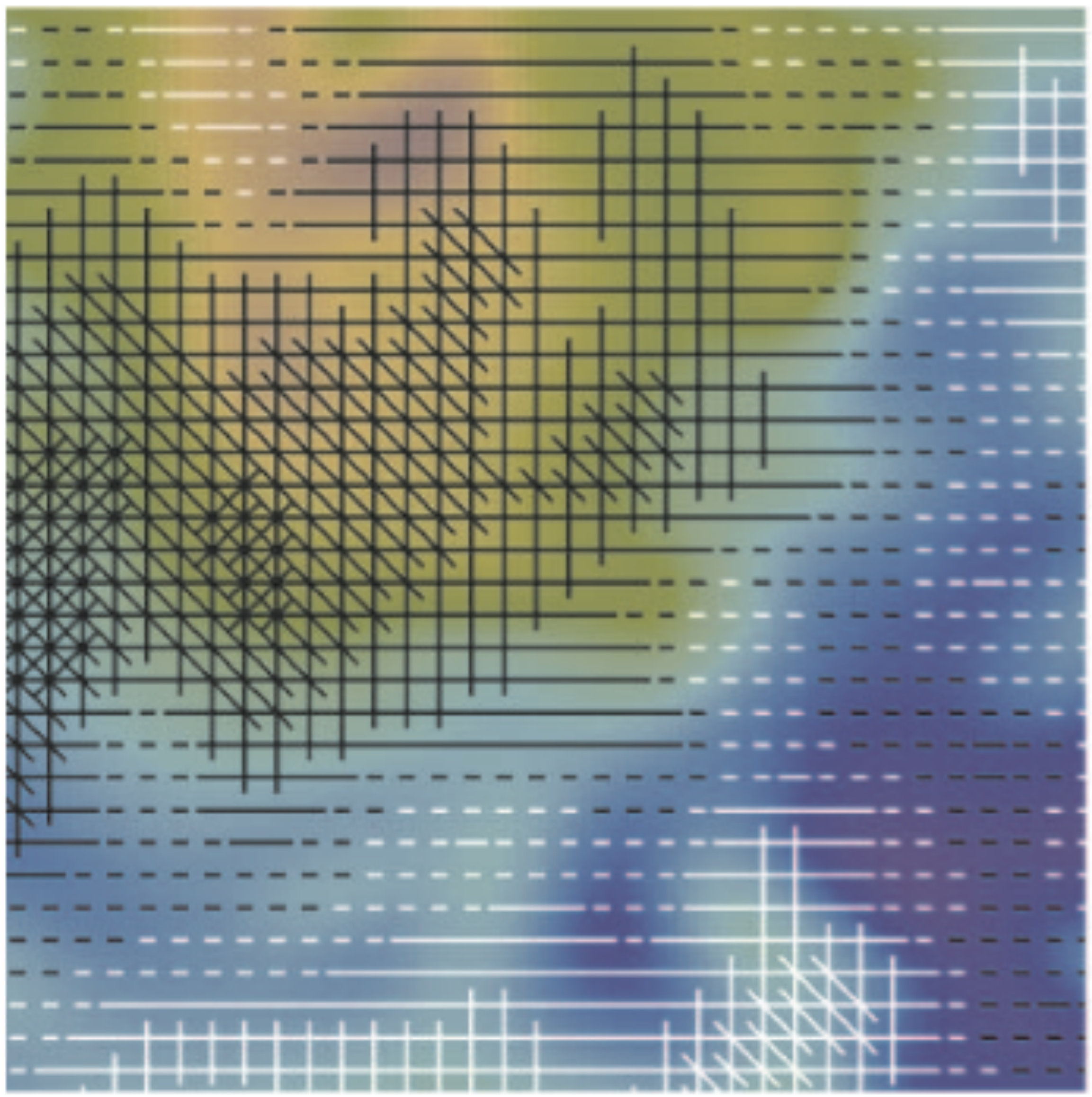
Scheme 1: Green Red (GR)

Scheme 2: Hue Lightness (HL)

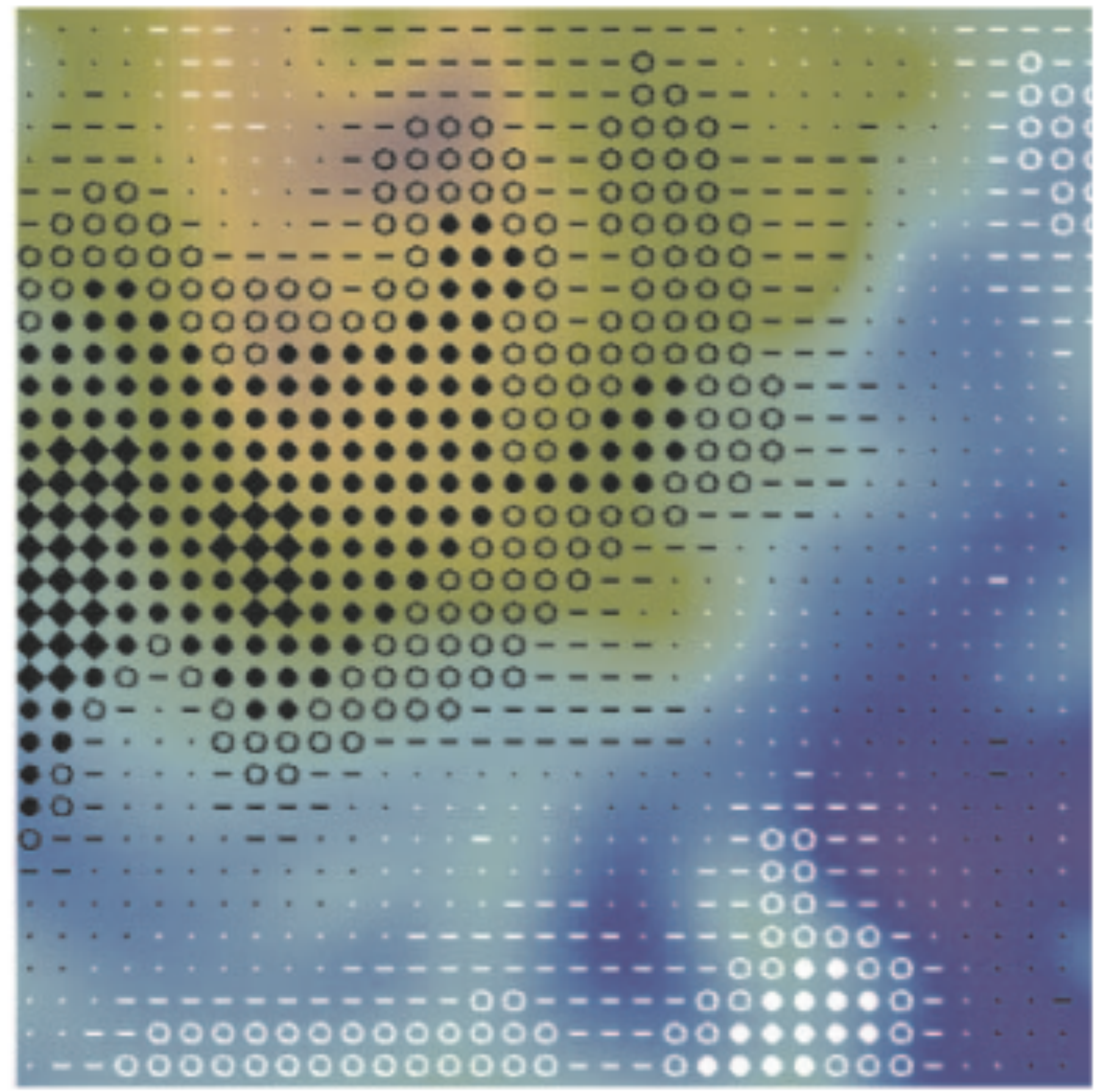
Ware 2009 TVCG

Recommended Reading for CS544 Students

Overlays for bivariate maps



Scheme 4: Spectrum QTonS 1 (QTS_1)



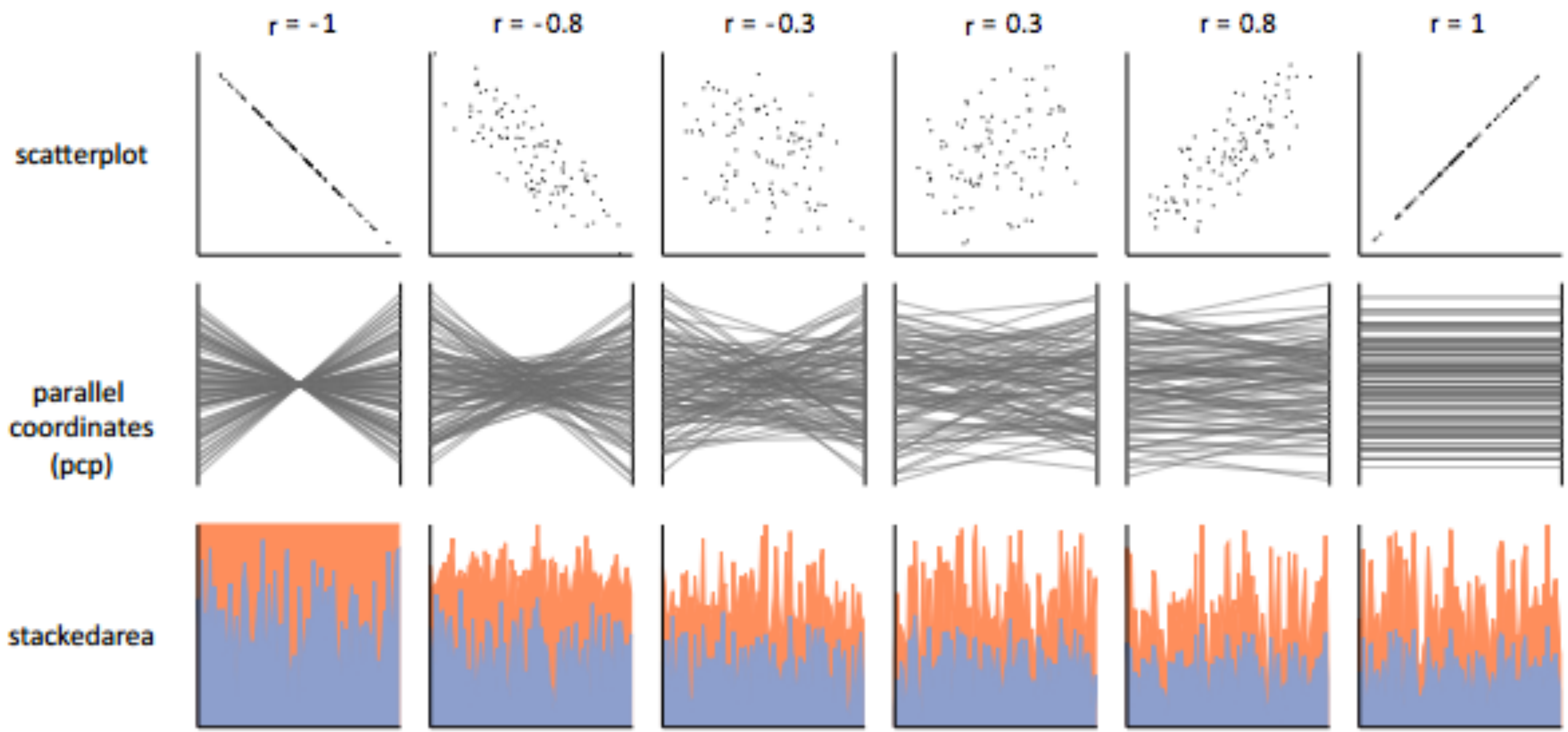
Scheme 5: Spectrum QTonS 2 (QTS_2)

Ware 2009 TVCG

Recommended Reading for CS544 Students

Perception of higher-level features

- Correlation perception follows Weber's Law (!)



Harrison et al., TVCG 2014

Recommended Reading for CS544 Students

Perception of higher-level features

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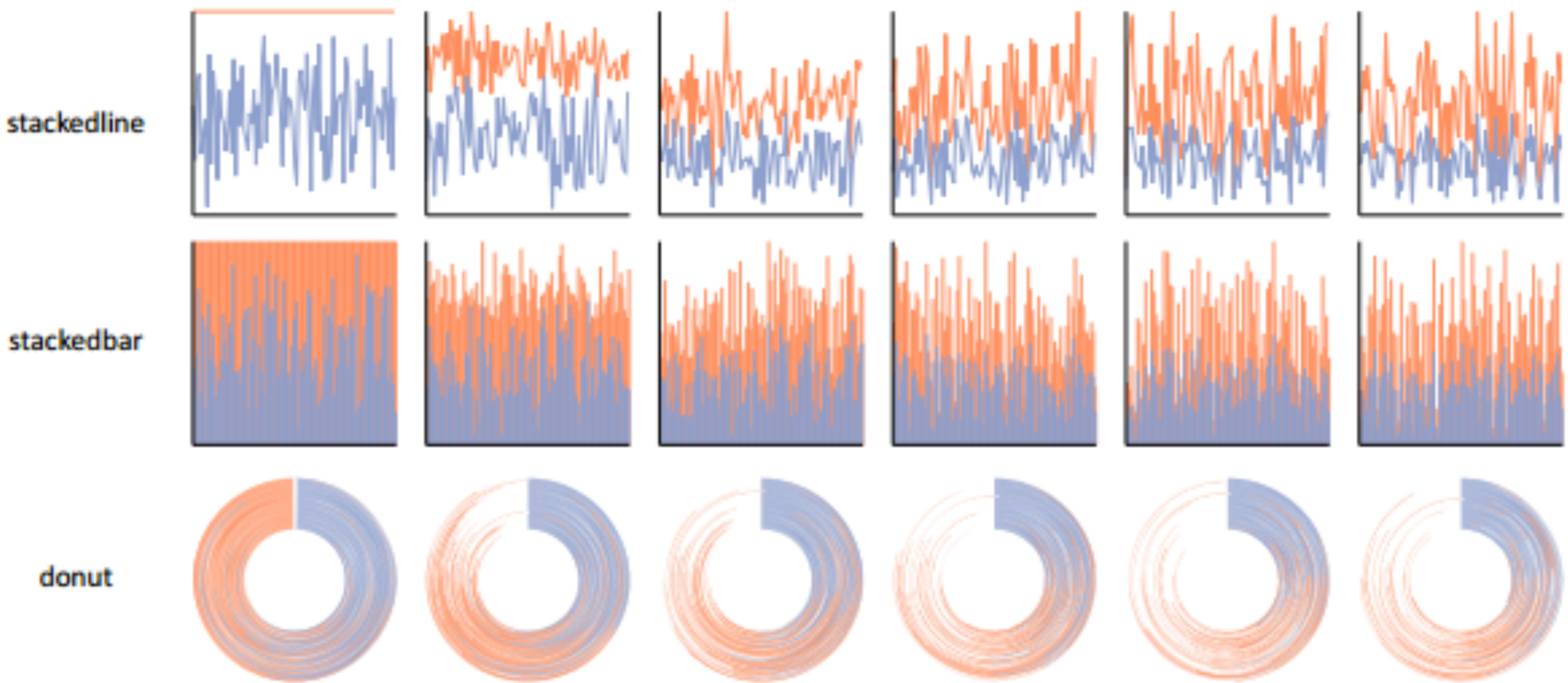

Harrison et al., TVCG 2014

Recommended Reading for CS544 Students

Perception of higher-level features

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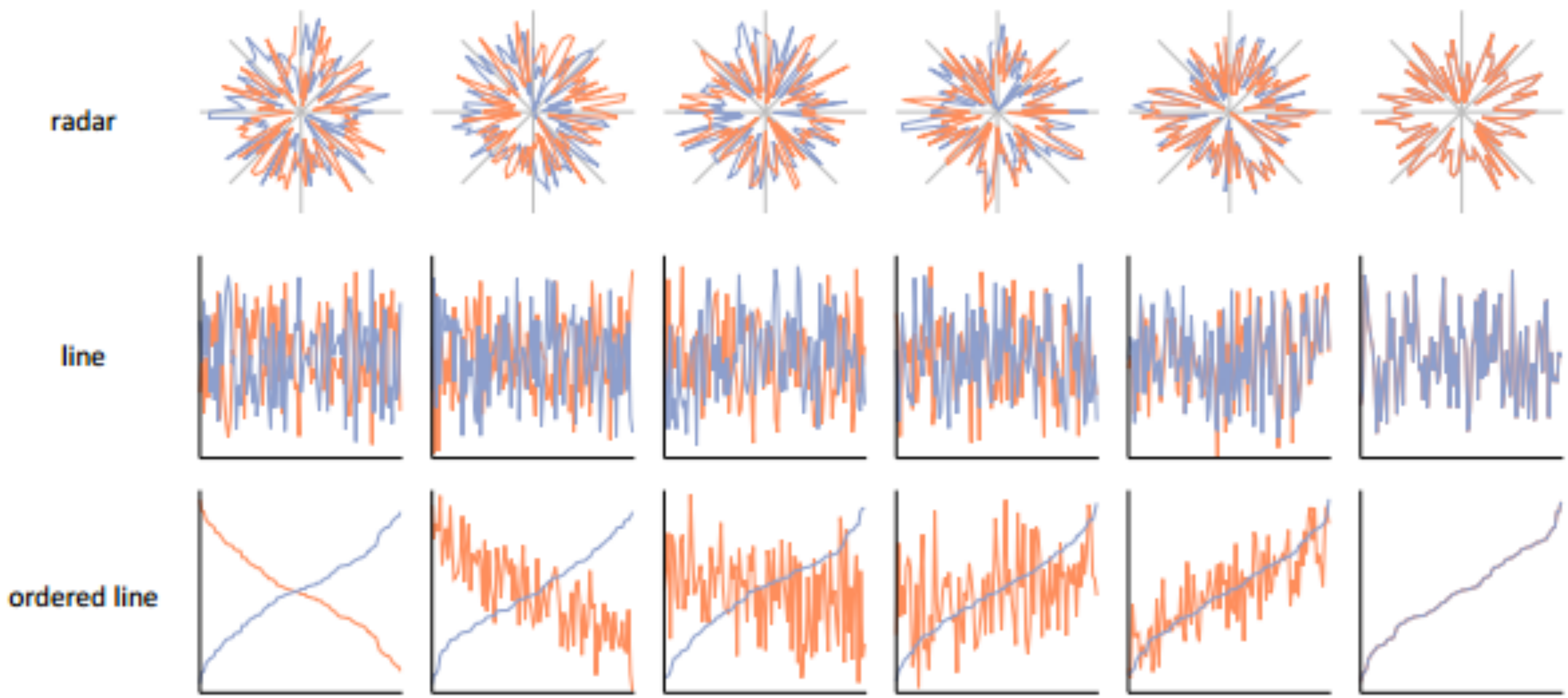


Harrison et al., TVCG 2014

Recommended Reading for CS544 Students

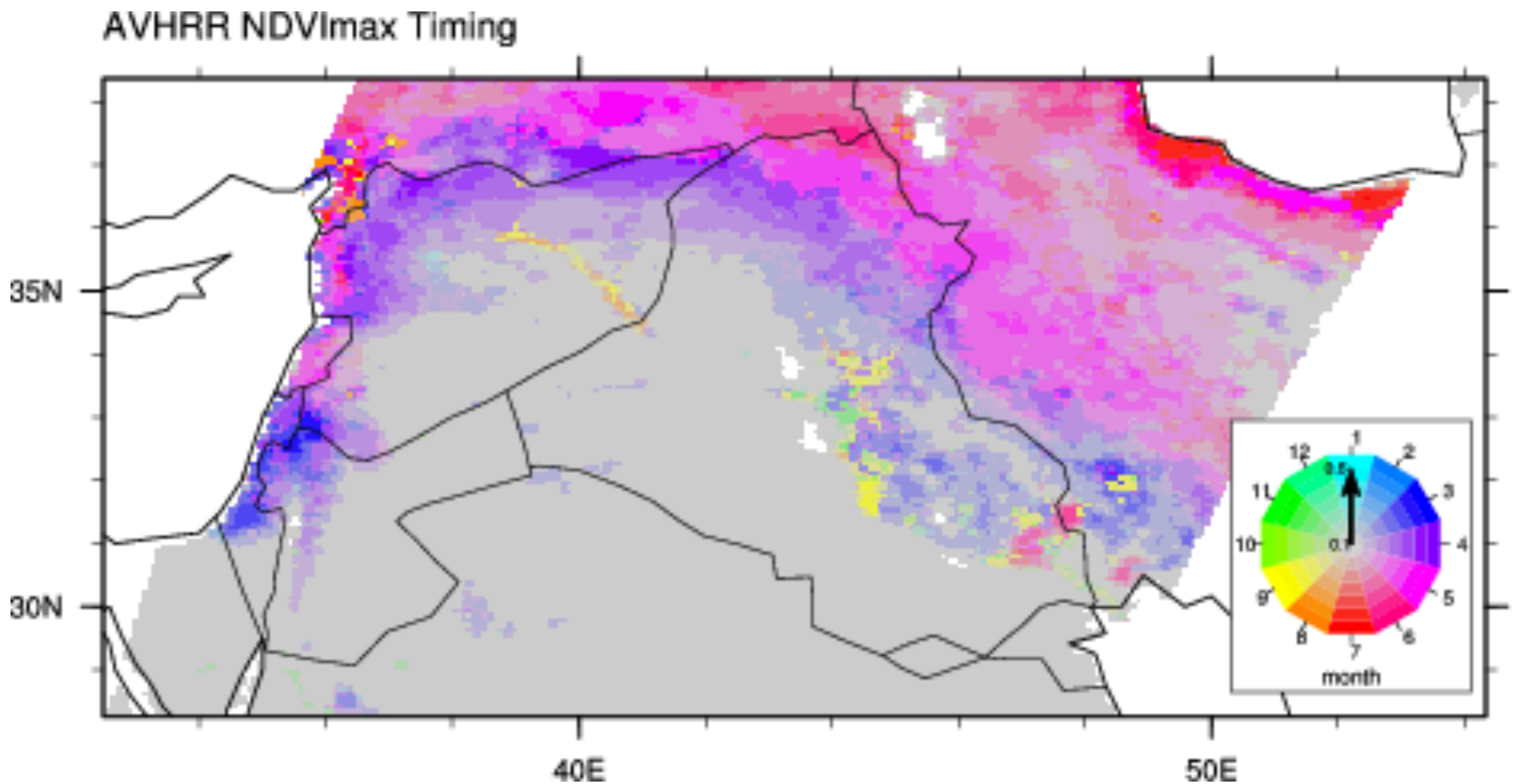
Recap

- Consider how data behaves
  - Can you add? Subtract? Compare? Is there a smallest, or are values just different from one another? Etc.
- Consider how the basic visual channels behave, match the two appropriately
- **But what if they don't?**

“WEIRD” DATA

(A prelude to techniques)

Orientation vs. Direction

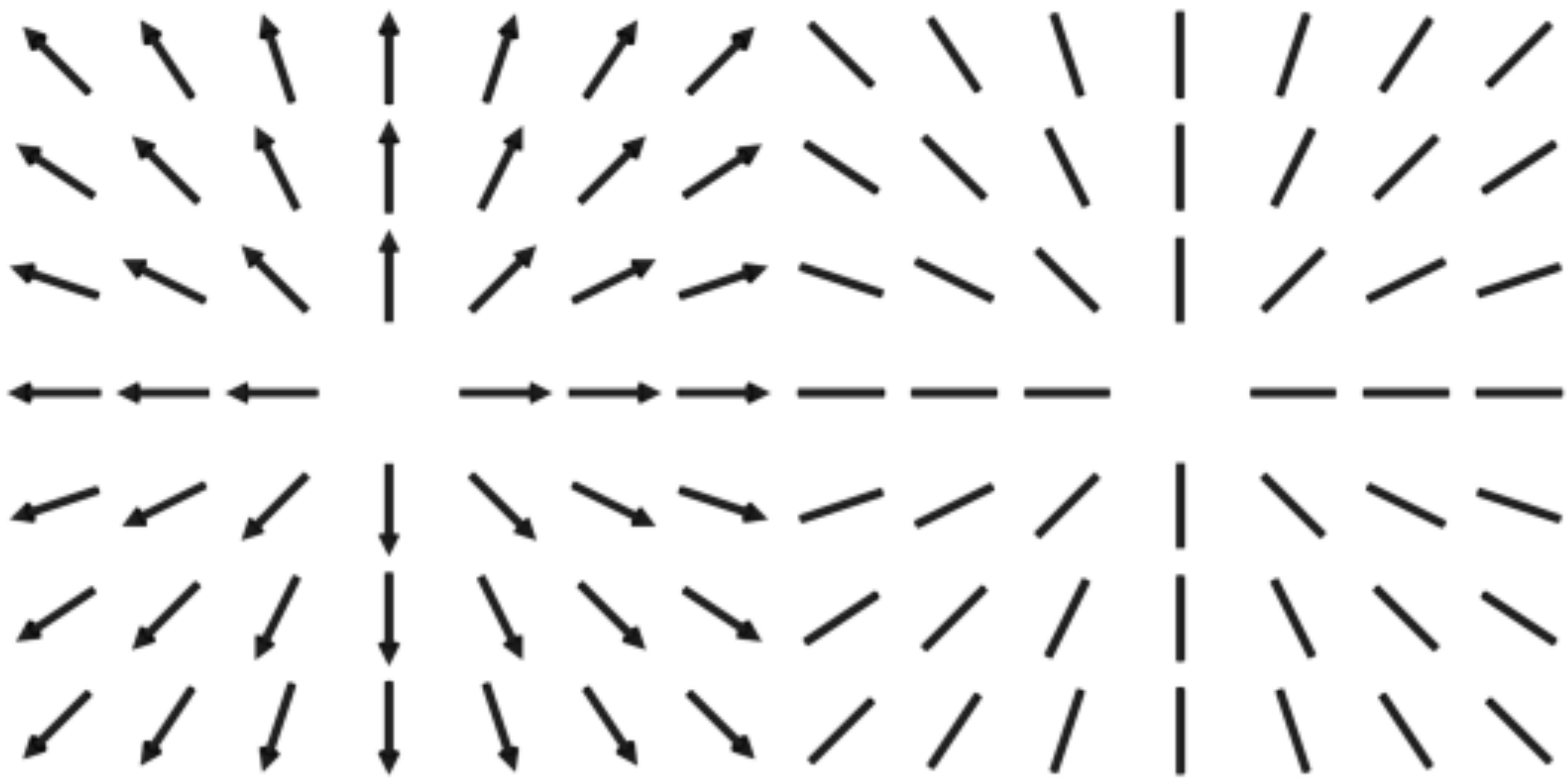


https://www.ncl.ucar.edu/Applications/evans.shtml

Orientation vs. Direction

http://www.datapointed.net/2014/10/maps-of-street-grids-by-orientation/

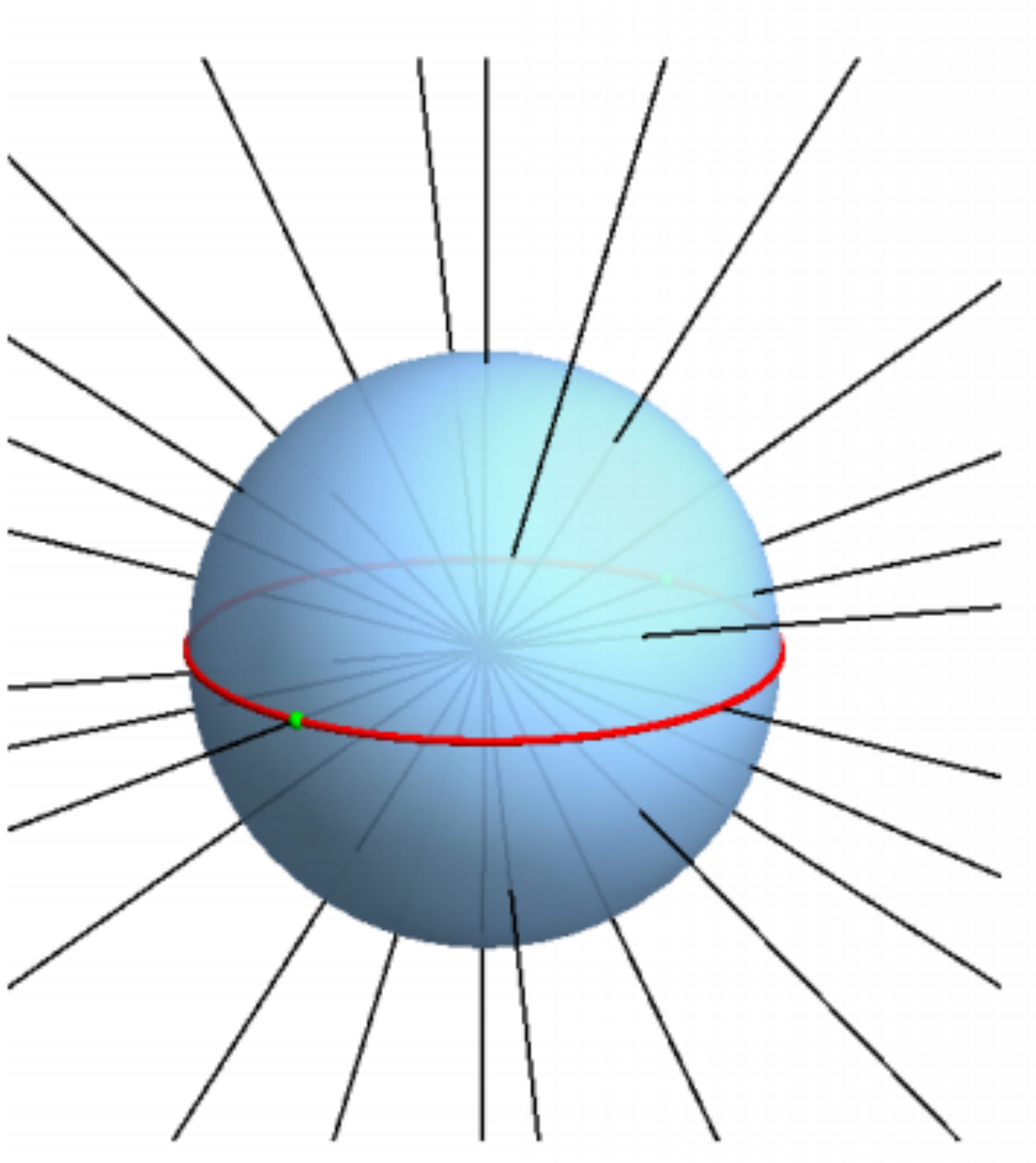
Orientation vs. Direction



(a) (b)

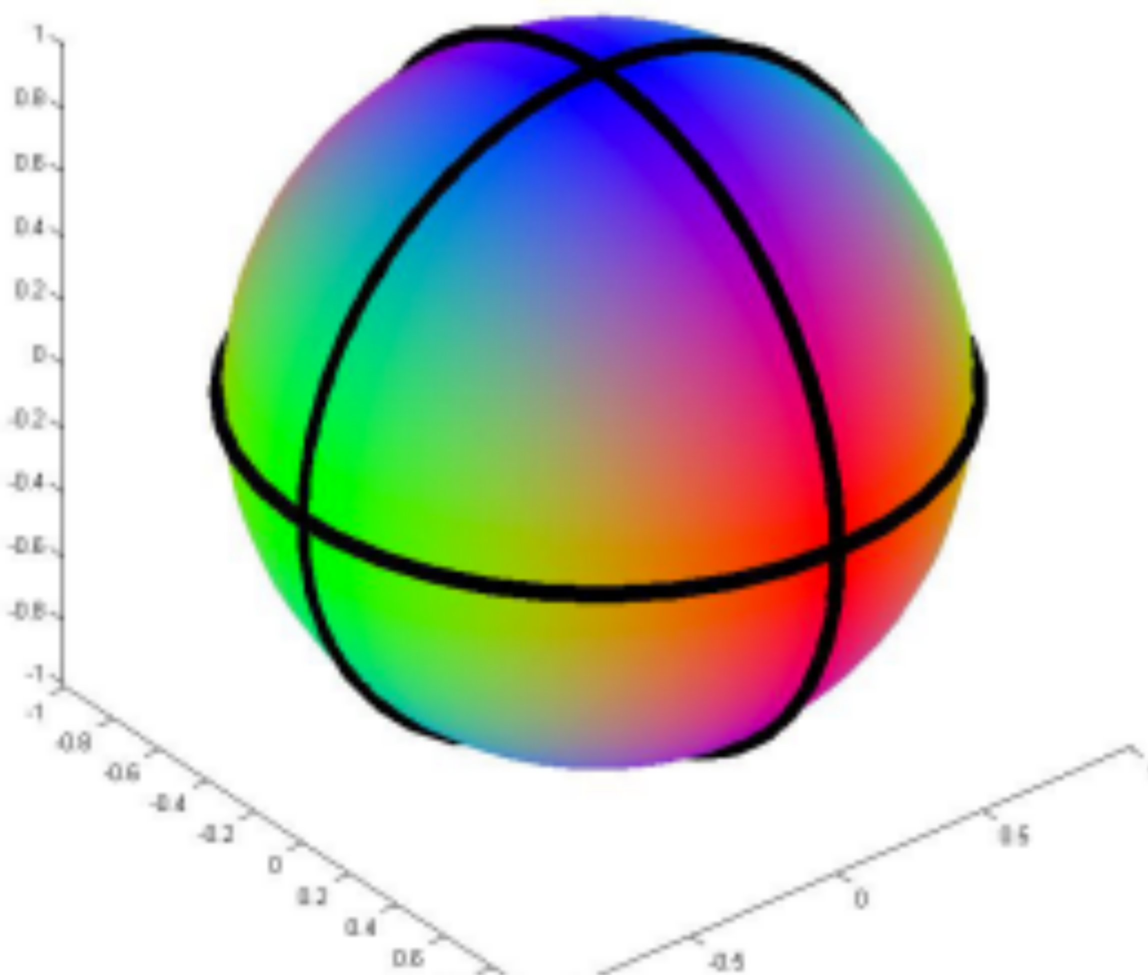
Demiralp et al. 2009

Orientation vs. Direction



Demiralp et al. 2009

Orientation vs. Direction



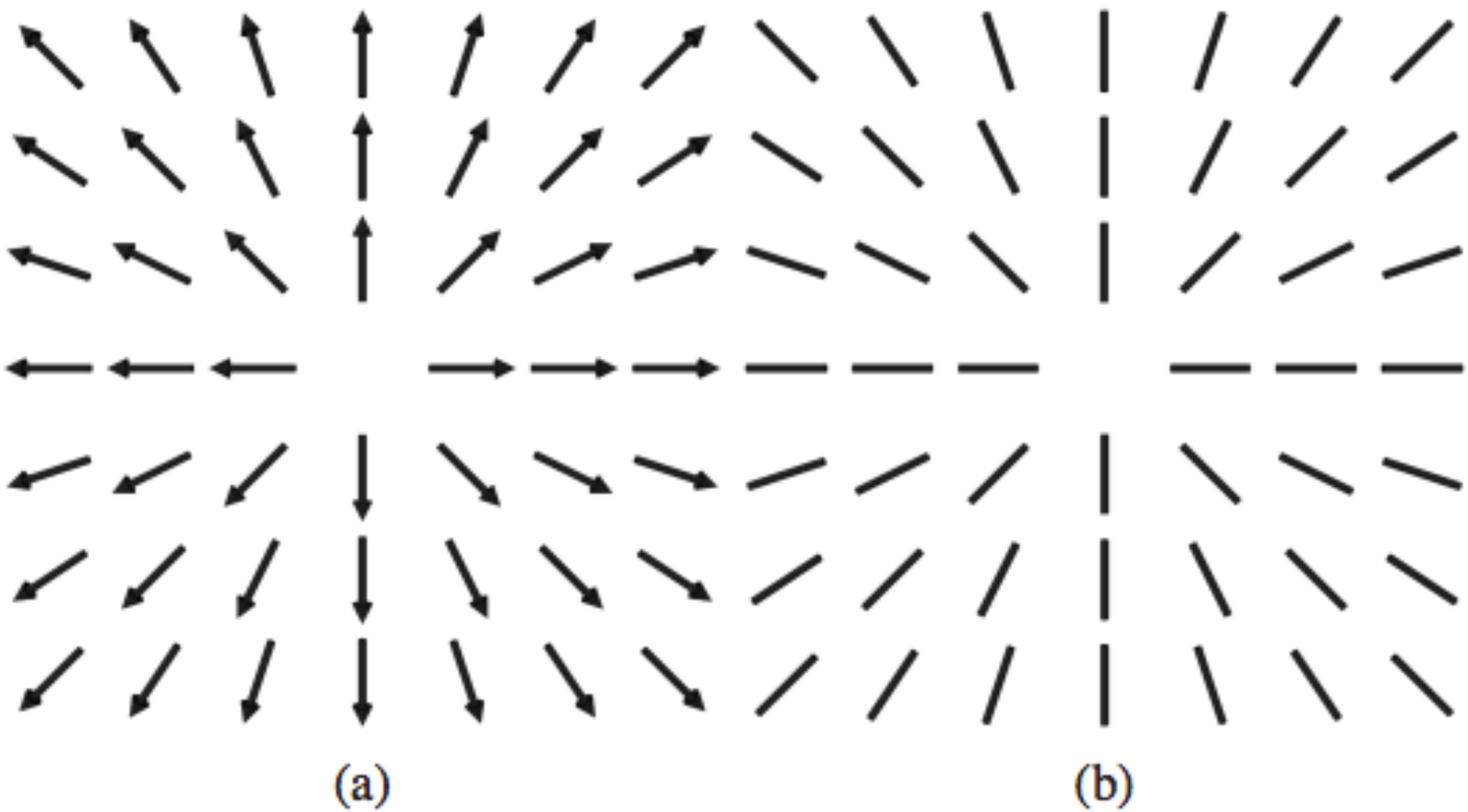
(c)

This is a bad colormap.

Why?

Demiralp et al. 2009

Orientation vs. Direction



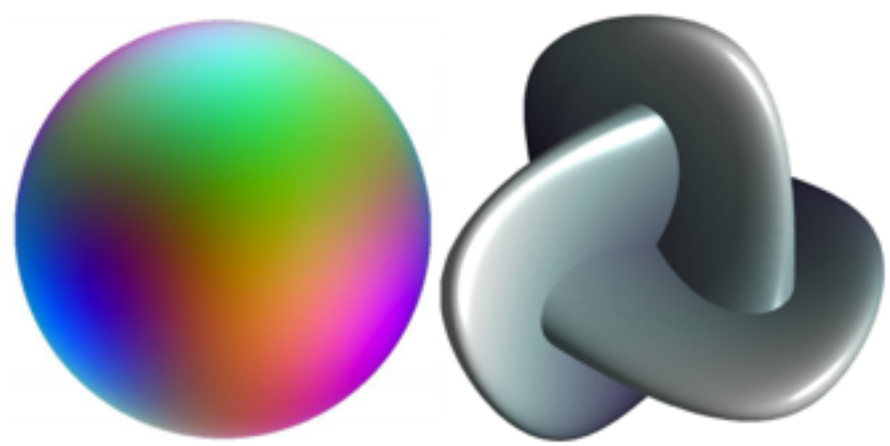
Demiralp et al. 2009

Orientation vs. Direction

Recommended Reading for CS544 Students

Coloring 3D Line Fields Using Boy's Real Projective Plane Immersion

Çağatay Demiralp, John F. Hughes, and David H. Laidlaw, *Senior Member, IEEE*



(a) (b)

Fig. 1: a) Sphere colored by immersing RP^2 in RGB color space b) Boy's surface

Abstract—We introduce a new method for coloring 3D line fields and show results from its application in visualizing orientation in DTI brain data sets. The method uses Boy's surface, an immersion of RP^2 in 3D. This coloring method is smooth and one-to-one except on a set of measure zero, the double curve of Boy's surface.

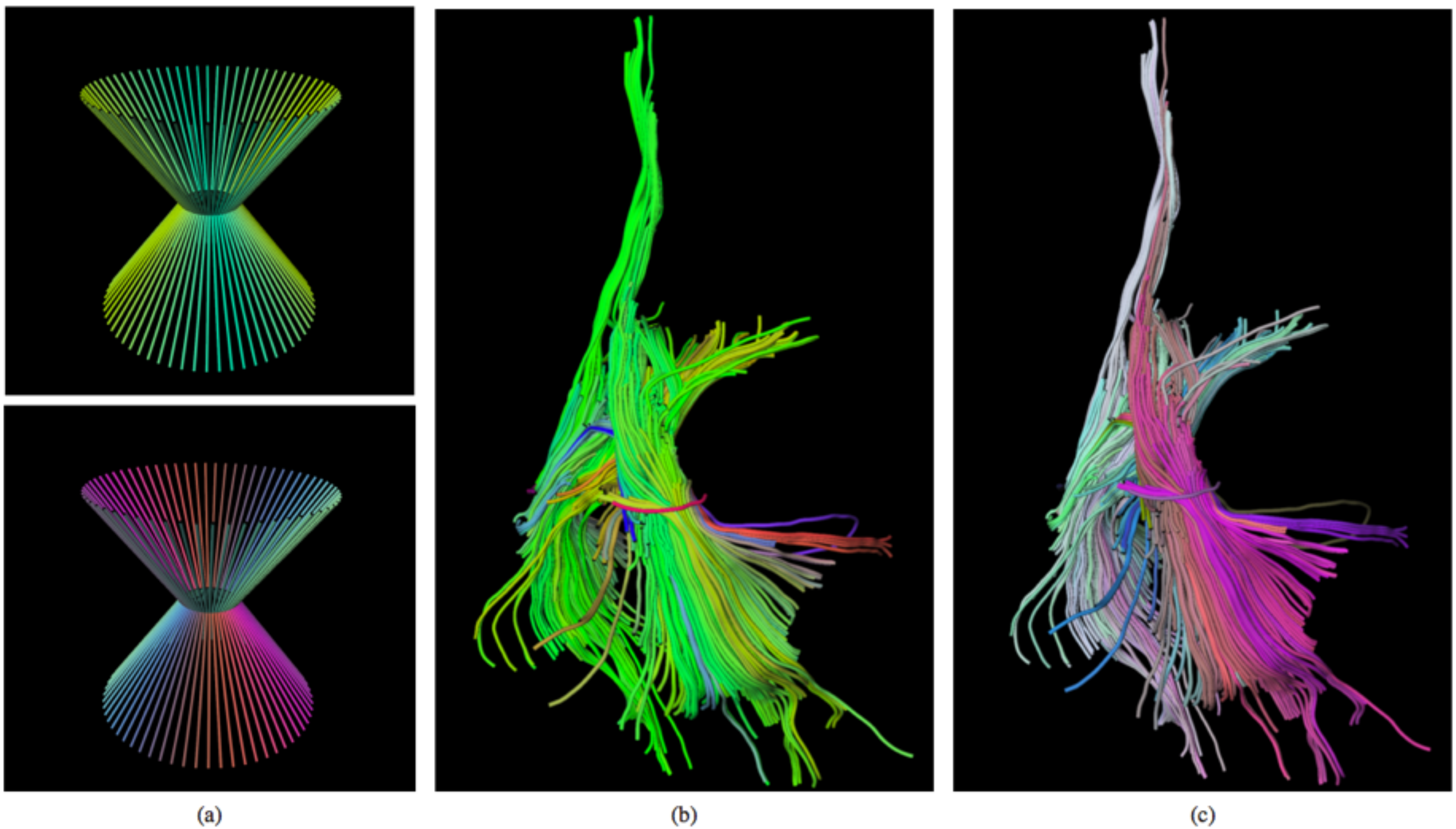
Index Terms—Line field, colormapping, orientation, real projective plane, tensor field, DTI.

1 Introduction

It is often useful to visualize a *line field*, a function that sends each point P of the plane or of space to a line through P (see Figure 2a,b);

show that no such mapping exists [9]: RP^2 is a nonorientable surface, it admits no embedding in 3-space.

Orientation vs. Direction



Demiralp et al. 2009

Probability Distributions

- Map behavior of conditional distributions, marginal distributions, etc. to visual channels: Product Plots, Wickham and Hoffman, TVCG 2011

Recommended Reading for CS544 Students

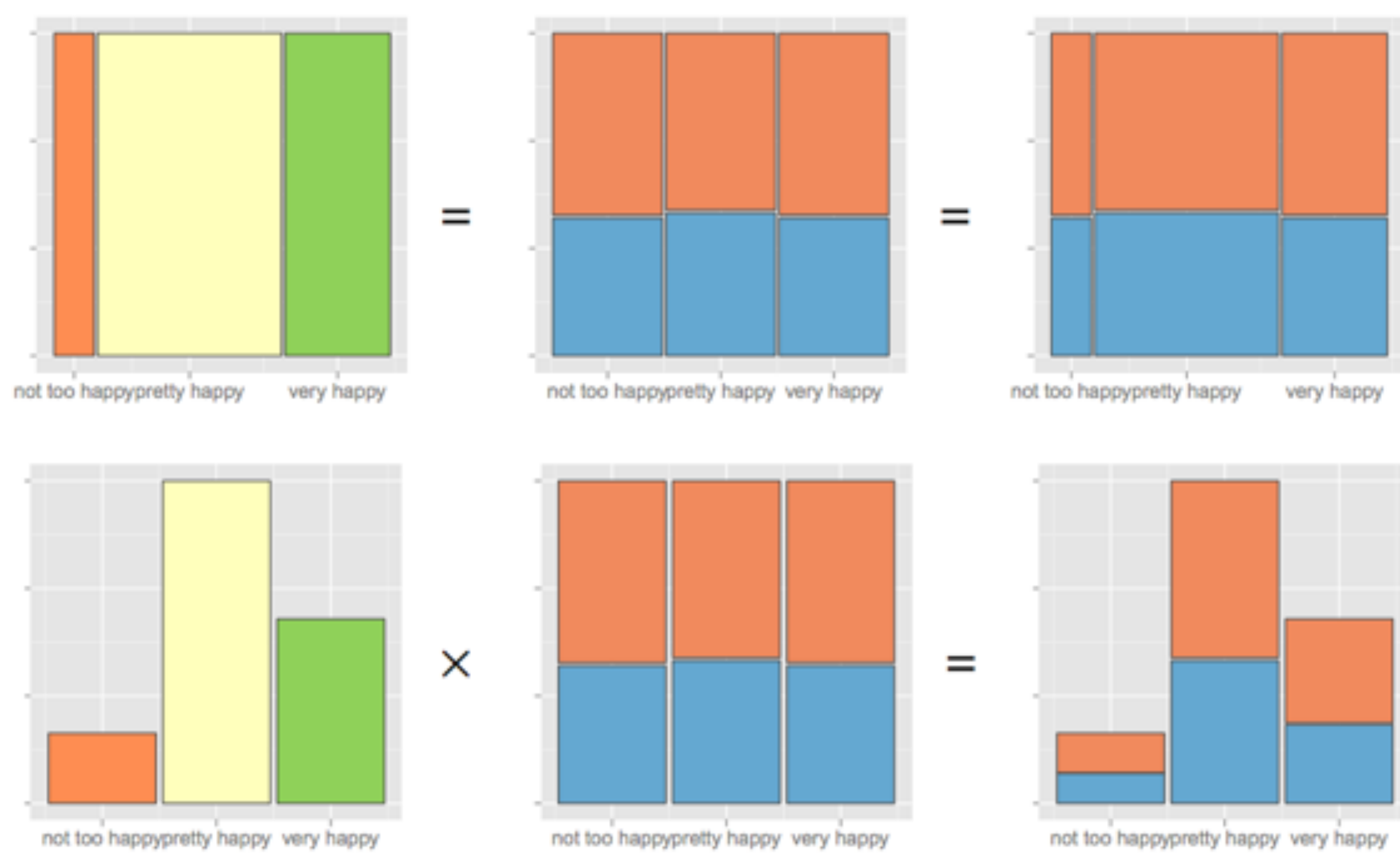
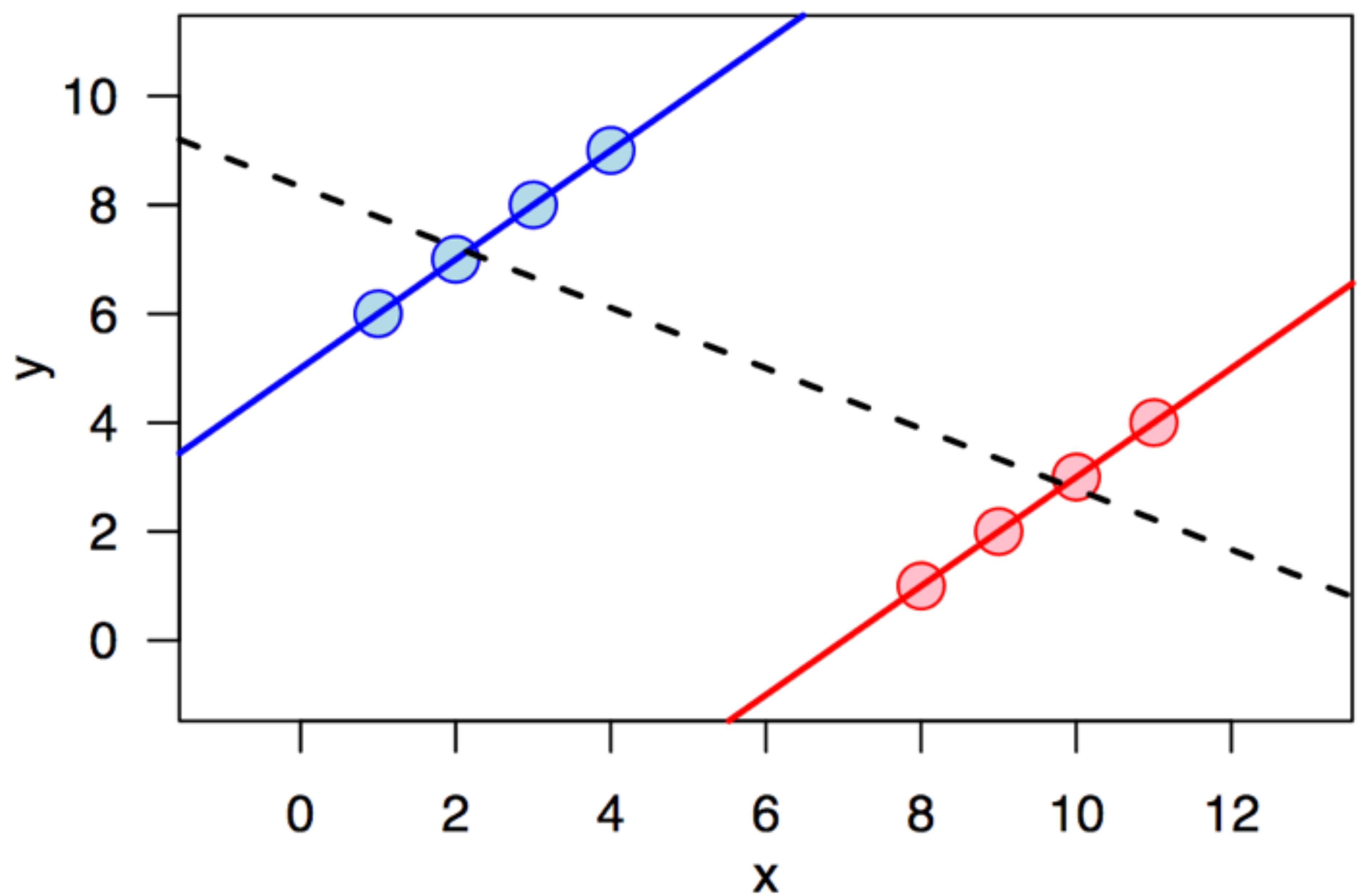


Fig. 5. Plots of the distribution of happiness and sex (■ male, ■ female) (Left) $f(happy)$, (Middle) $f(sex|happy)$, (Right) $f(happy, sex)$.

Simpson's "Paradox"



Simpson's "Paradox"

Table 1: Change in Median Wage by Education from 2000 to 2013

Segment	Change in Median Wage (%)
Overall	+0.9%
No degree	-7.9%
HS, no college	-4.7%
Some college	-7.6%
Bachelor's +	-1.2%

Simpson's "Paradox"

Segment	Employed 2000	Employed 2013	Change (%)
Overall	89.4	95.0	+6.4%
No degree	8.8	7.0	-21.3%
HS, no college	28.0	25.0	-10.6%
Some college	24.7	26.0	+5.4%
Bachelor's +	27.8	37.0	+33.0%

Simpson's "Paradox"

Recommended Reading for CS544 Students