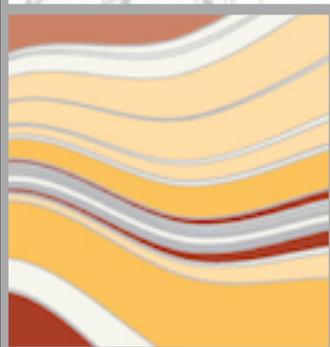
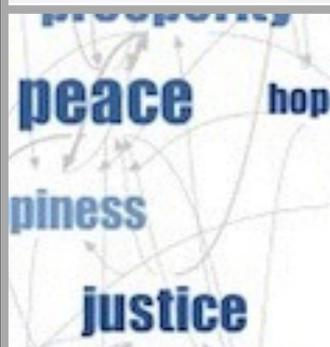
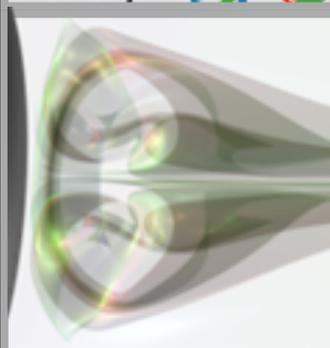
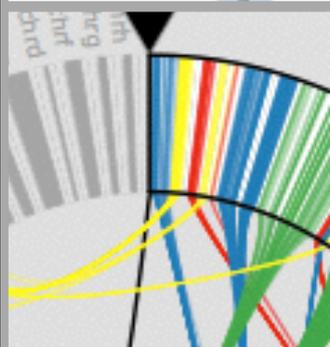
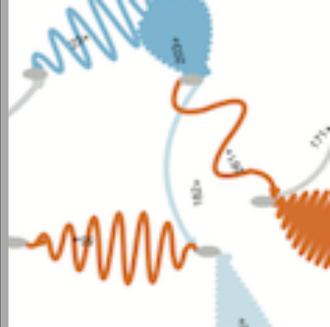


VISUAL ENCODING

Miriah Meyer
University of Utah



administrivia . . .

-introducing Dr. Josh Levine

last time . . .

data abstraction

the *what* part of an analysis that pertains to the data

translation of domain-specific terms into words that are as generic as possible

type vs semantics

data types

→ Items

→ Attributes

→ Links

→ Positions

→ Grids

dataset types

Tables

Items

Attributes

Networks &
Trees

Items (nodes)

Links

Attributes

Fields

Grids

Positions

Attributes

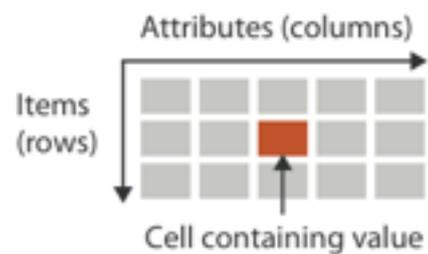
Geometry

Items

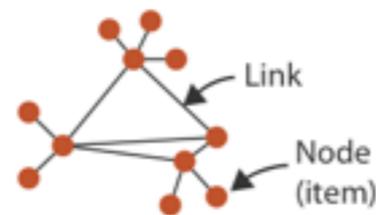
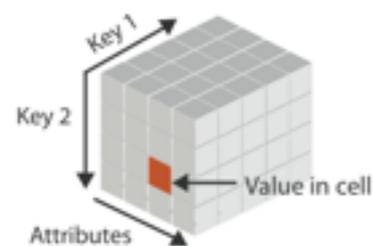
Positions

Clusters,
Sets, Lists

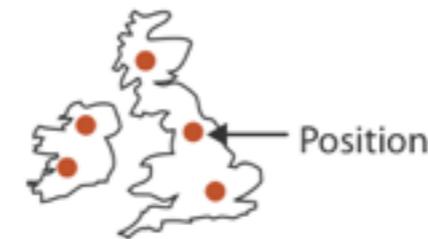
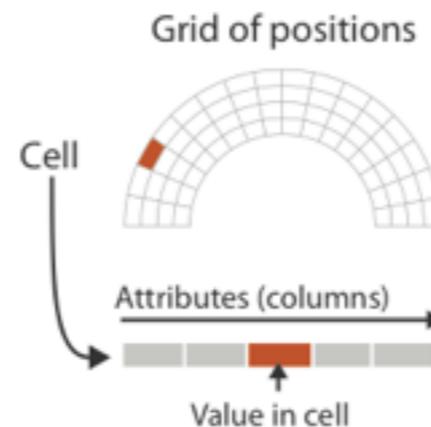
Items



→ *Multidimensional Table*

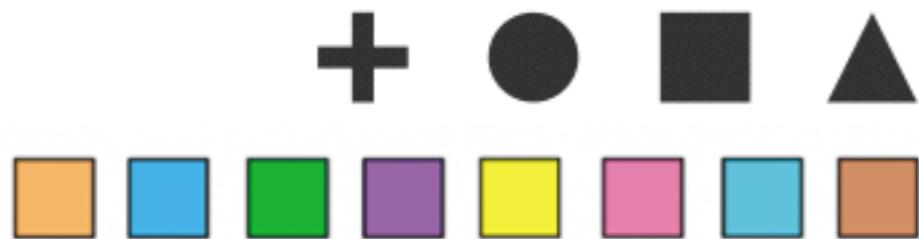


→ *Trees*



attribute types

→ Categorical
no implicit ordering

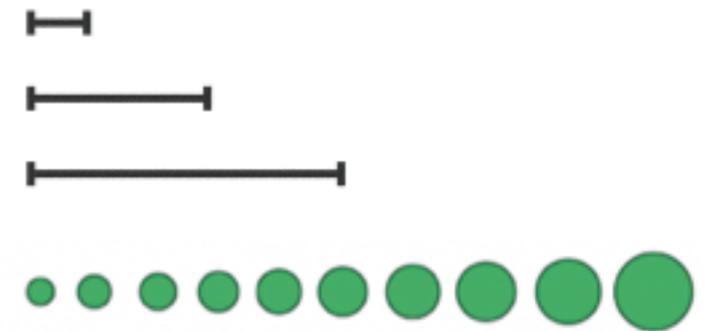


→ Ordered

→ Ordinal



→ Quantitative
meaningful magnitude,
can do arithmetic



→ Hierarchical

→ Sequential



→ Diverging



→ Cyclic



special

attribute semantics

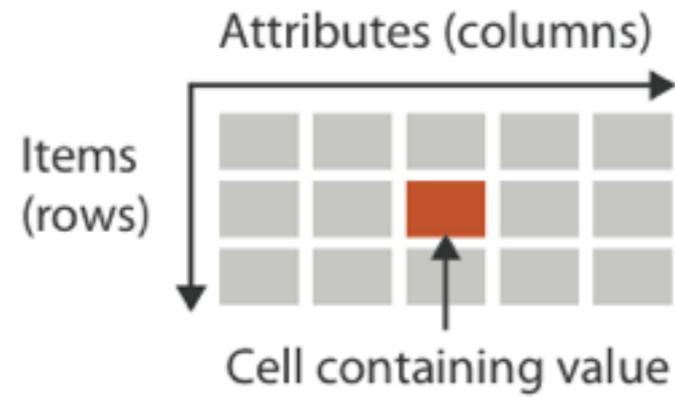
key vs value

special

attribute semantics

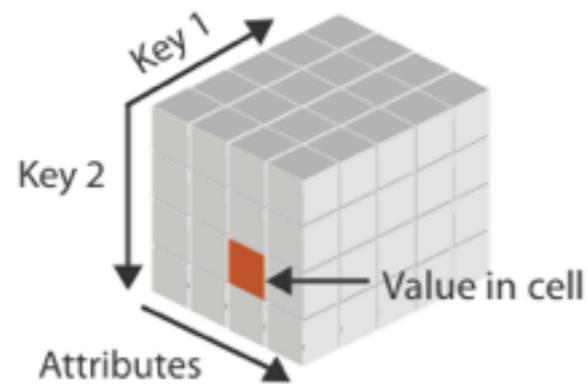
key vs value

flat



tables

multidimensional

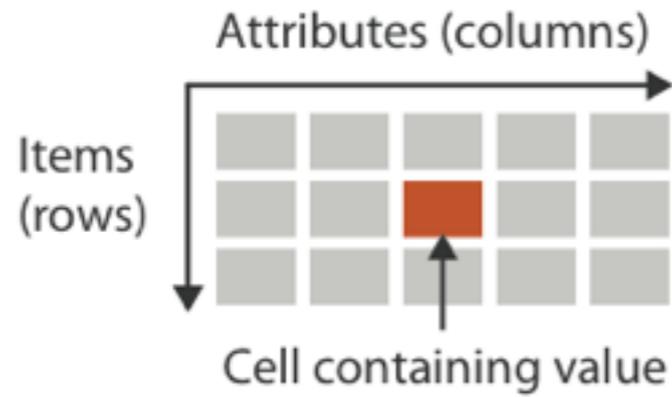


special

attribute semantics

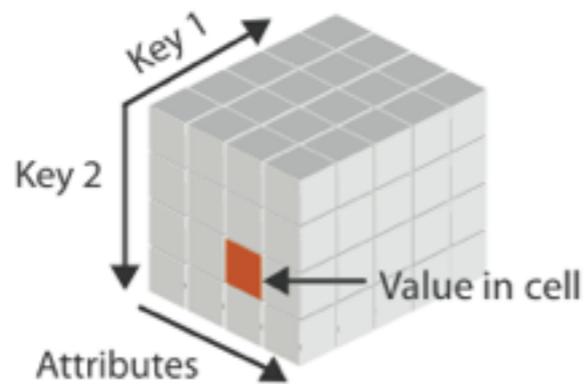
key vs value

flat

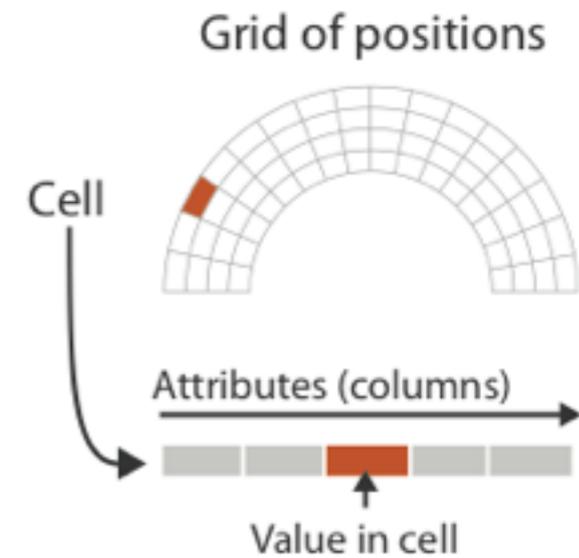


tables

multidimensional



fields



special

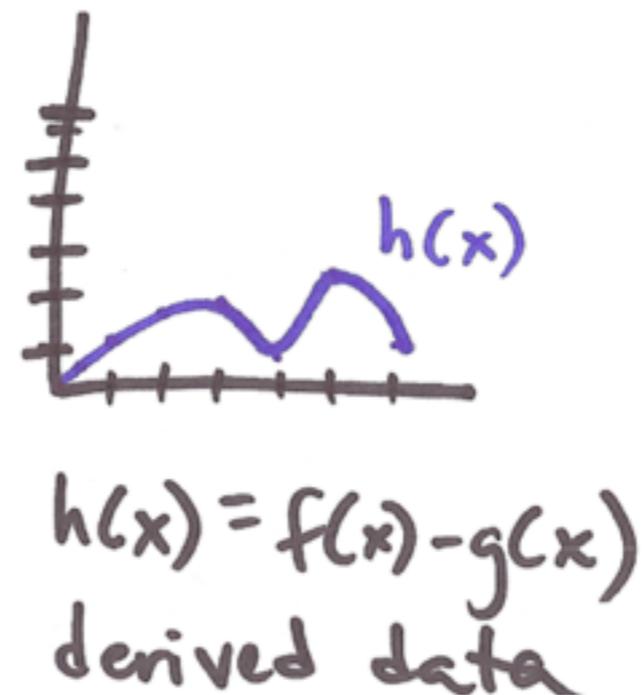
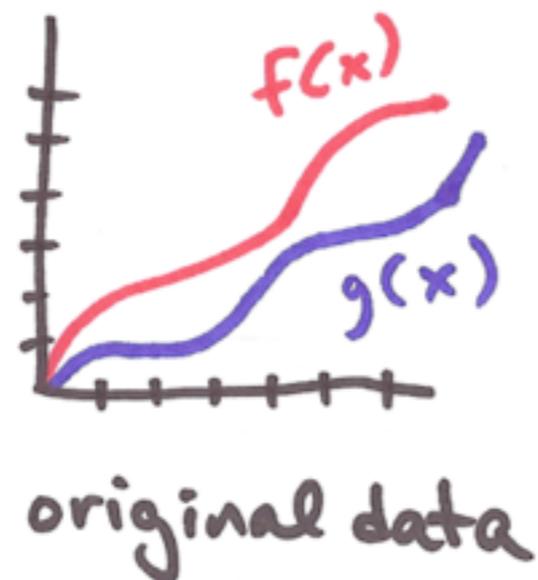
attribute semantics

temporal

what makes time special?

DERIVED ATTRIBUTES

- derived attribute: compute from originals
 - simple change of type
 - acquire additional data
 - complex transformation
 - transformation is abstraction choice



today . . .

-marks and channels

-planar position

-time

-color

-marks and channels

-planar position

-time

-color

MARKS

- graphical element in an image
- classified according to number of spatial dimensions required



points (0D)



lines (1D)



areas (2D)

CHANNELS

-parameters that control the appearance of marks

→ Position

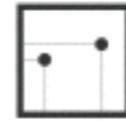
→ Horizontal



→ Vertical



→ Both



→ Color



→ Shape



→ Tilt



→ Size

→ Length

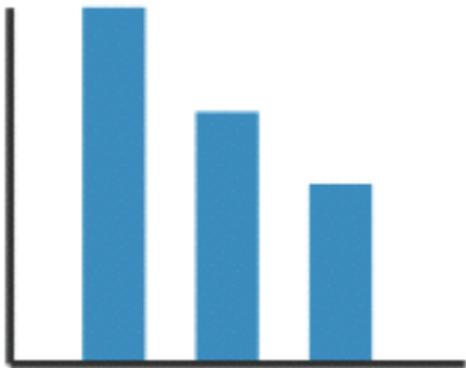


→ Area



→ Volume





TYPES

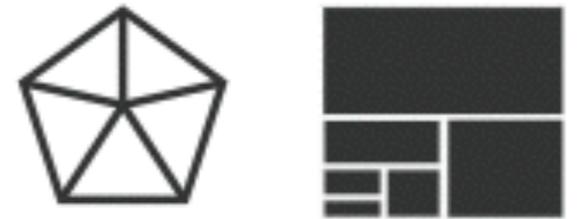
MARK TYPES



points (0D)



lines (1D)



areas (2D)

MARK TYPES

marks as nodes (items)



points (0D)



lines (1D)



areas (2D)

MARK TYPES

marks as nodes (items)



points (0D)



lines (1D)

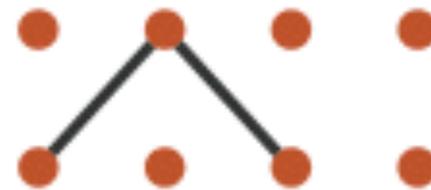


areas (2D)

marks as links



containment



connection

CHANNEL TYPES

→ Position

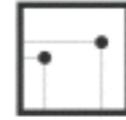
→ Horizontal



→ Vertical



→ Both



→ Color



→ Shape



→ Tilt



→ Size

→ Length



→ Area



→ Volume



CHANNEL TYPES

identity (what or where)

magnitude (how much)

→ Position

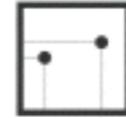
→ Horizontal



→ Vertical



→ Both



→ Color



→ Shape



→ Tilt



→ Size

→ Length



→ Area



→ Volume



CHANNEL TYPES

identity (what or where)

magnitude (how much)

➔ Position

➔ Horizontal ➔ Vertical ➔ Both



➔ Color



➔ Shape



➔ Tilt



➔ Size

➔ Length ➔ Area



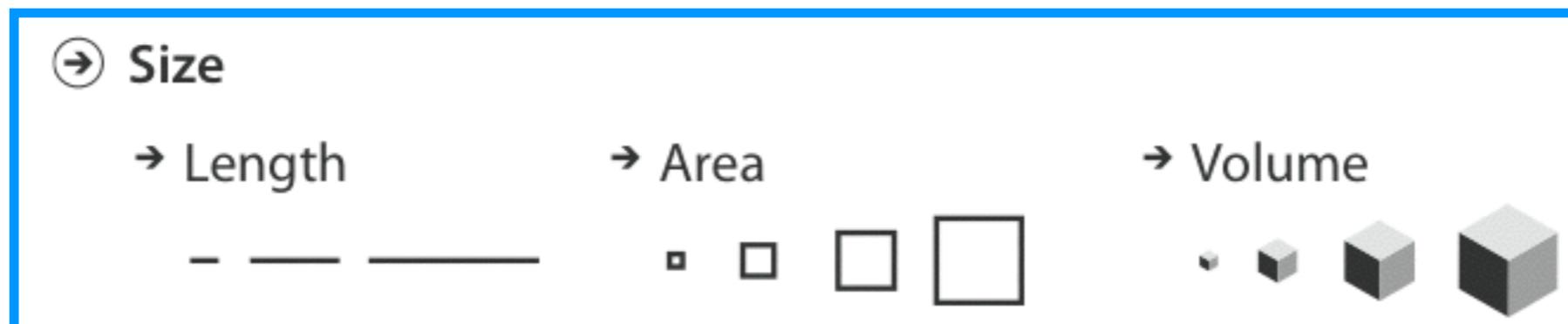
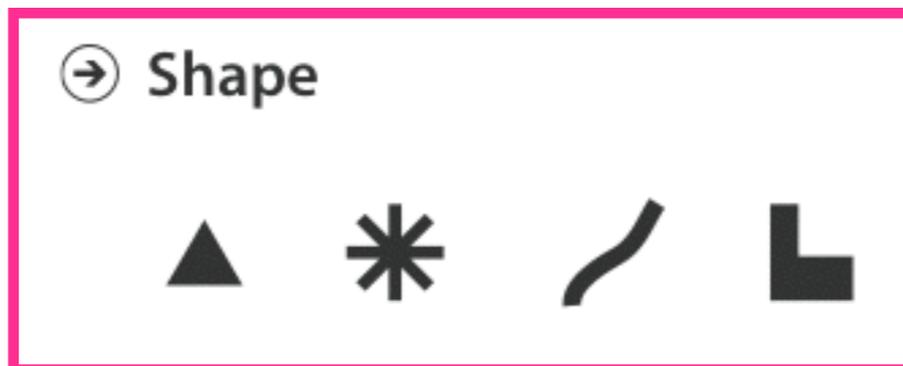
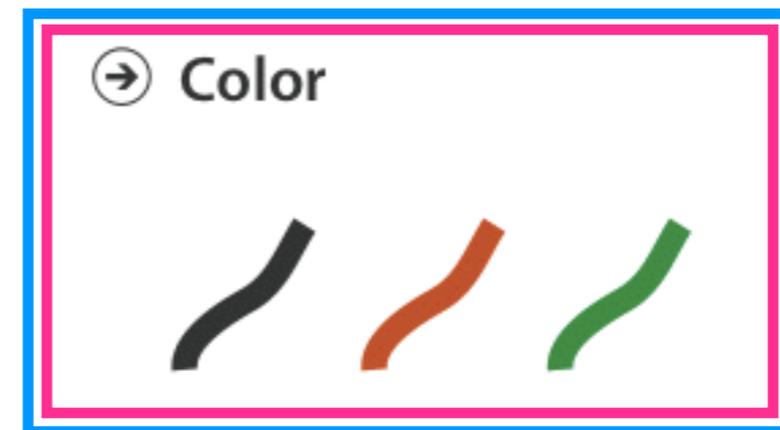
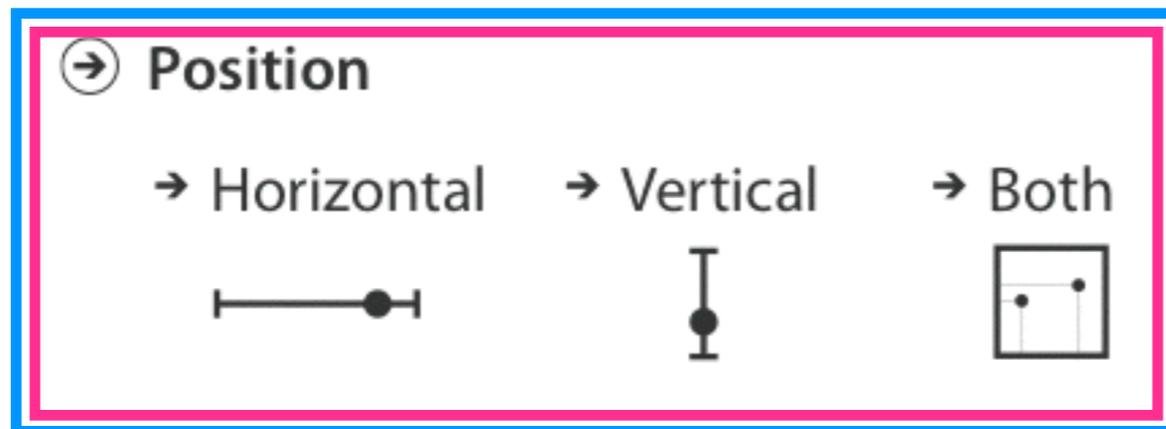
➔ Volume



CHANNEL TYPES

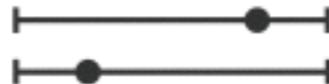
identity (what or where)

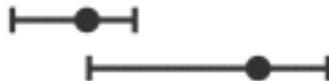
magnitude (how much)



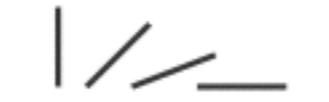
expressiveness & effectiveness

➔ **Magnitude Channels: Ordered Attributes**

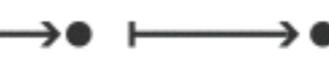
Position on common scale 

Position on unaligned scale 

Length (1D size) 

Tilt/angle 

Area (2D size) 

Depth (3D position) 

Color luminance 

Color saturation 

Curvature 

Volume (3D size) 

➔ **Identity Channels: Categorical Attributes**

Spatial region 

Color hue 

Motion 

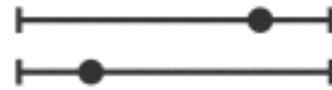
Shape 

expressiveness

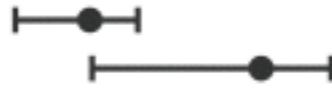
(how much)

➔ **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)



(what or where)

➔ **Identity Channels: Categorical Attributes**

Spatial region



Color hue



Motion



Shape



expressiveness

➔ **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

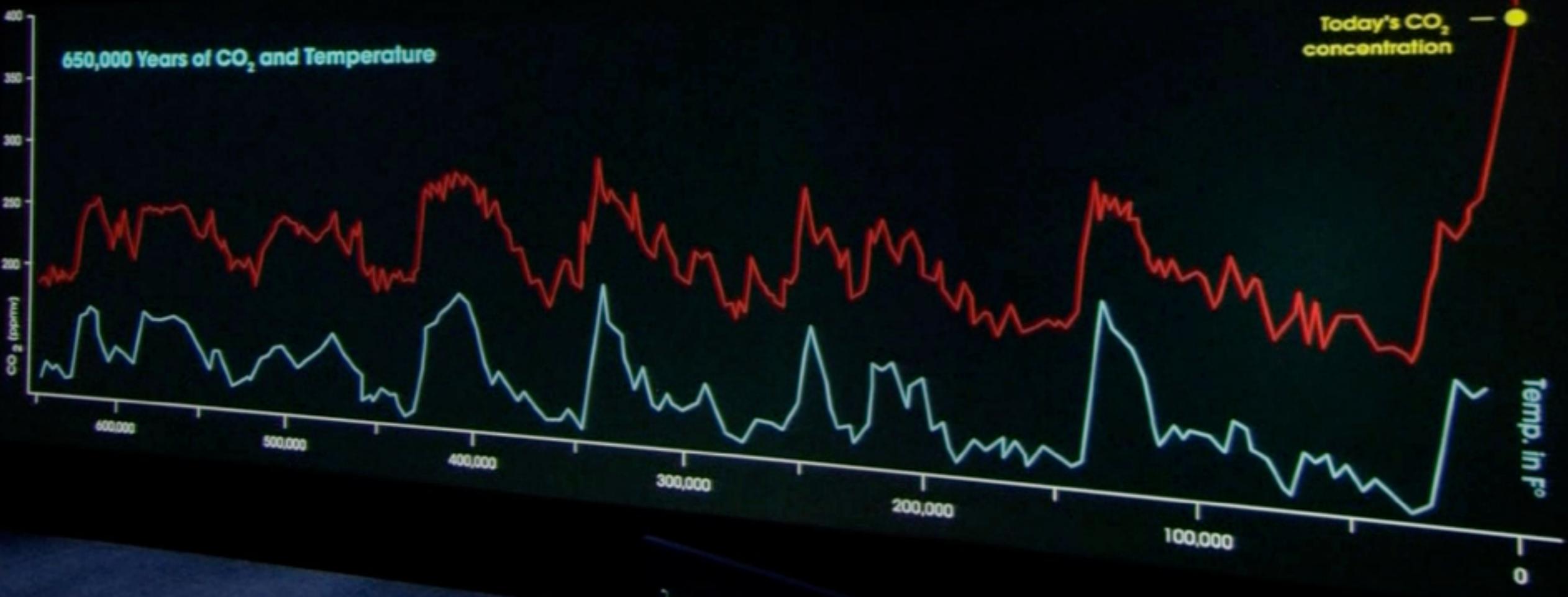
➔ **Identity Channels: Categorical Attributes**

- Spatial region 
- Color hue 
- Motion 
- Shape 

Effectiveness

effectiveness

name that channel . . .



Projected concentration after 50 more years of unrestricted fossil fuel burning

Today's CO₂ concentration



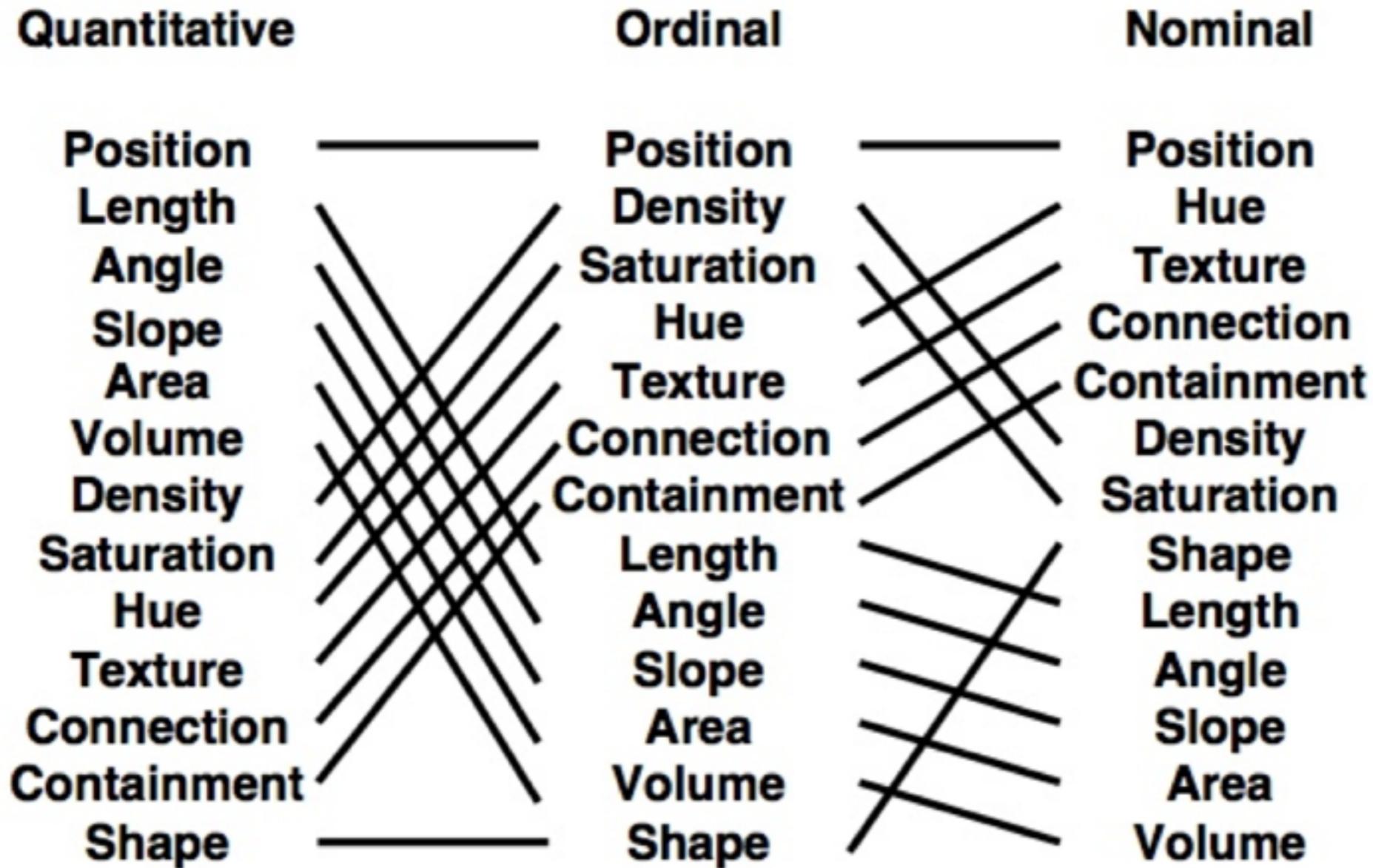
WHERE DO RANKINGS COME FROM?

Bertin, 1967

O = Ordinal, Q = Quantitative
 ≠ = Differences ≡ = Similarities

VARIABLES OF THE IMAGE			POINT	LINE	AREA (ZONE)
XY 2 DIMENSIONS OF THE PLANE		OQ ≠	x x x		
	SIZE	OQ ≠			
Z	VALUE	O ≠			
DIFFERENTIAL VARIABLES					
	TEXTURE	O ≠			
	COLOR	≡ ≠			
	ORIENTATION	≡ ≠			
	SHAPE	≡ ≠			

Mackinlay, 1986



Cleveland & McGill, 1984

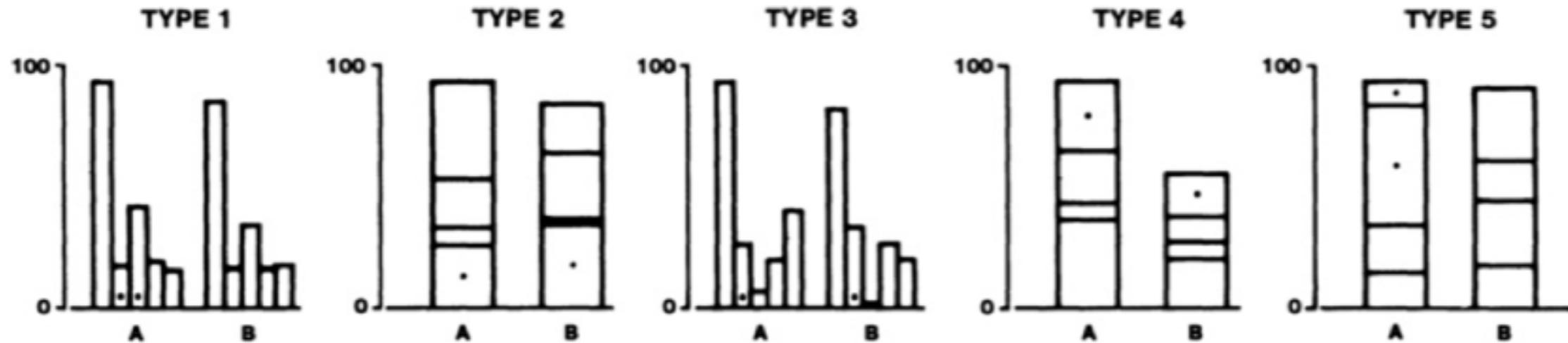


Figure 4. Graphs from position-length experiment.

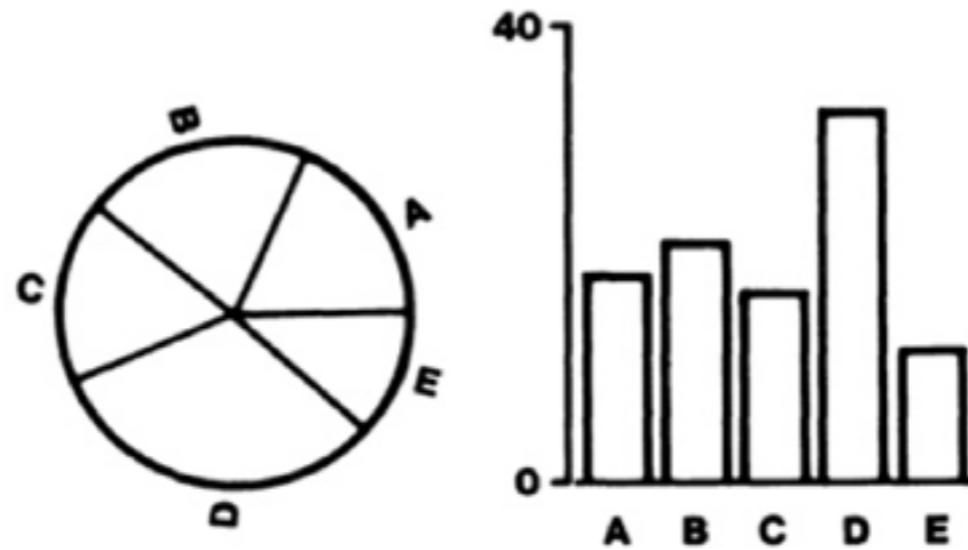


Figure 3. Graphs from position-angle experiment.

Heer & Bostock, 2010

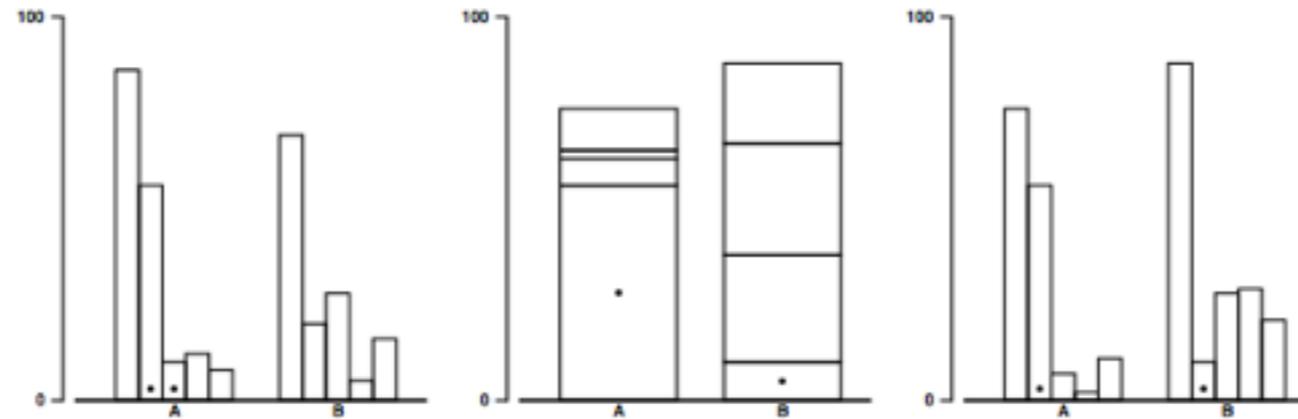


Figure 1: Stimuli for judgment tasks T1, T2 & T3. Subjects estimated percent differences between elements.

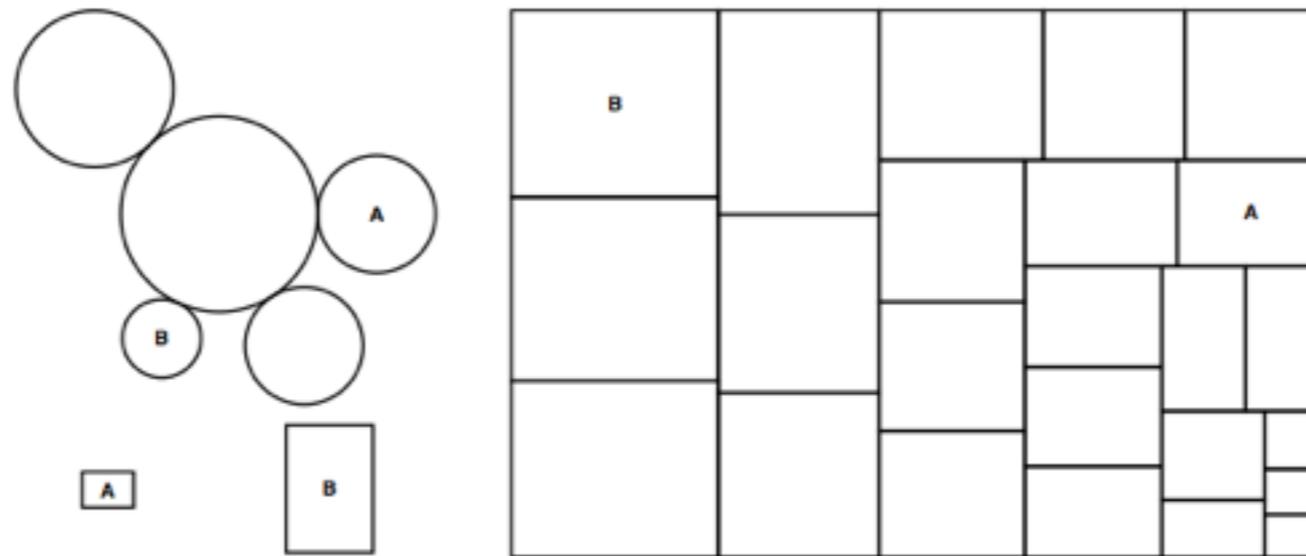
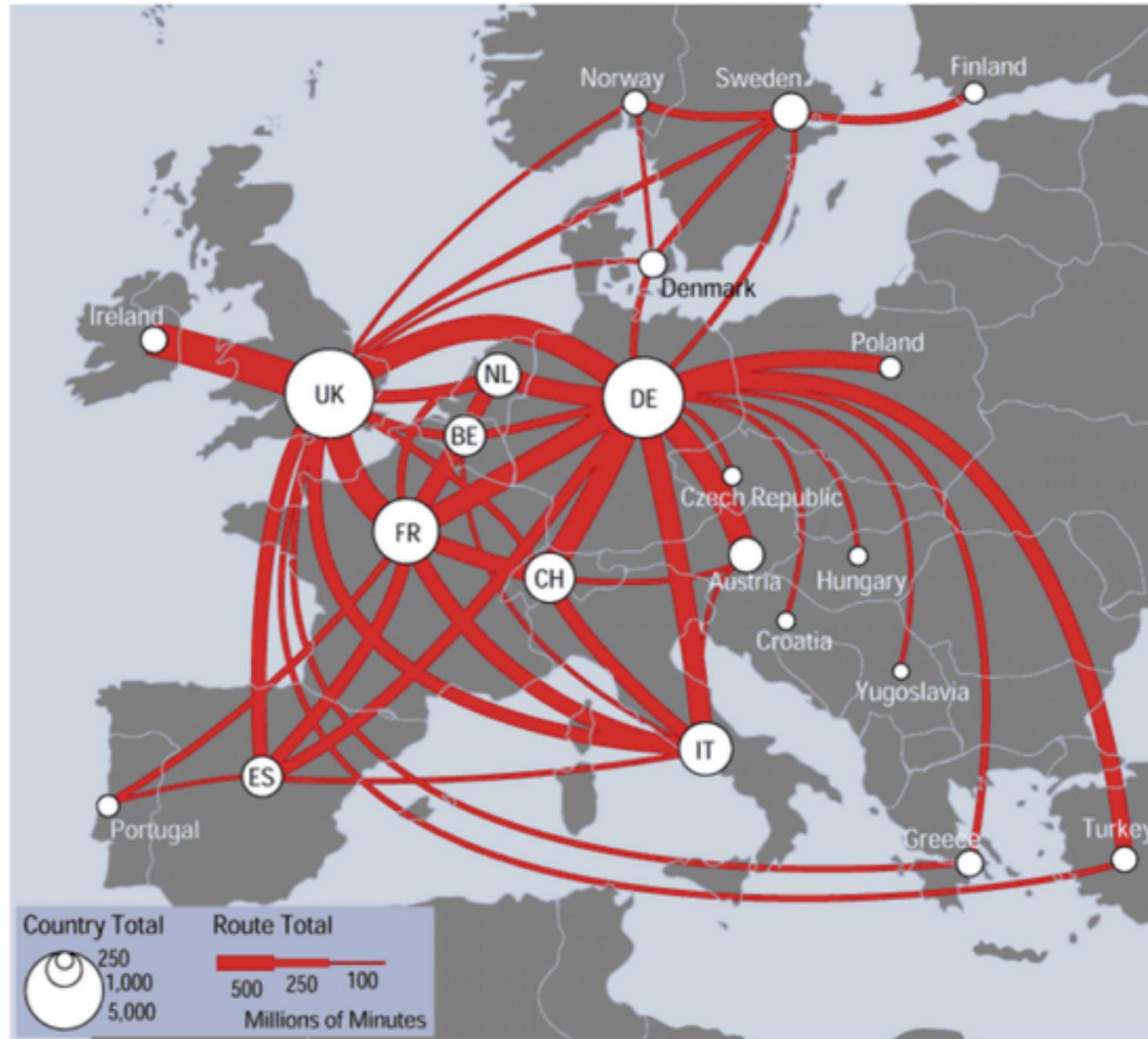


Figure 2: Area judgment stimuli. Top left: Bubble chart (T7), Bottom left: Center-aligned rectangles (T8), Right: Treemap (T9).

DISCRIMINABILITY

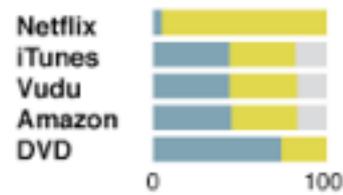
can channel differences be discerned?



Streaming the Box Office

Top 100 in 2011

■ AVAILABLE
■ NOT AVAILABLE
■ PURCHASE ONLY

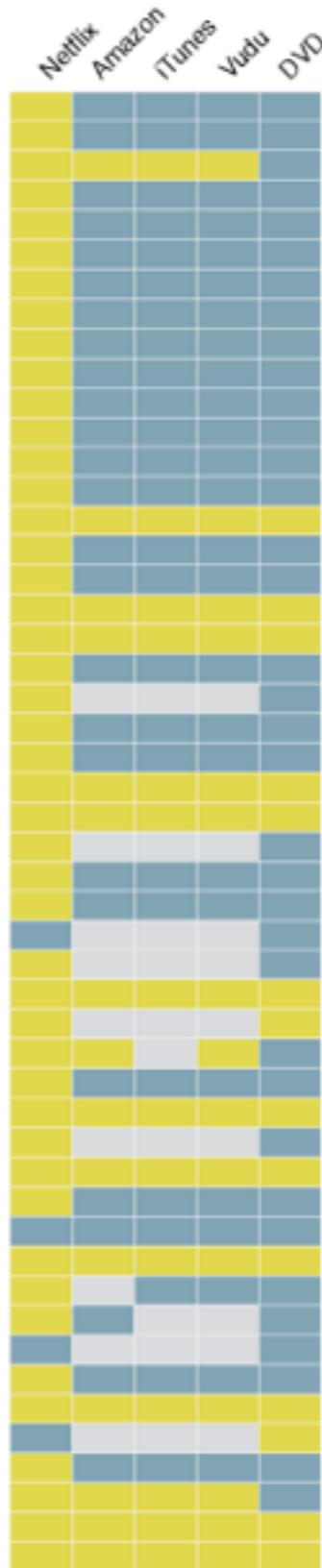


Tristan Louis compiled a list of the top 100 movies at the box office, according to Box Office Mojo, that were available streaming. This is a graphical version of that list.

Source: Tristan Louis
By: Nathan Yau

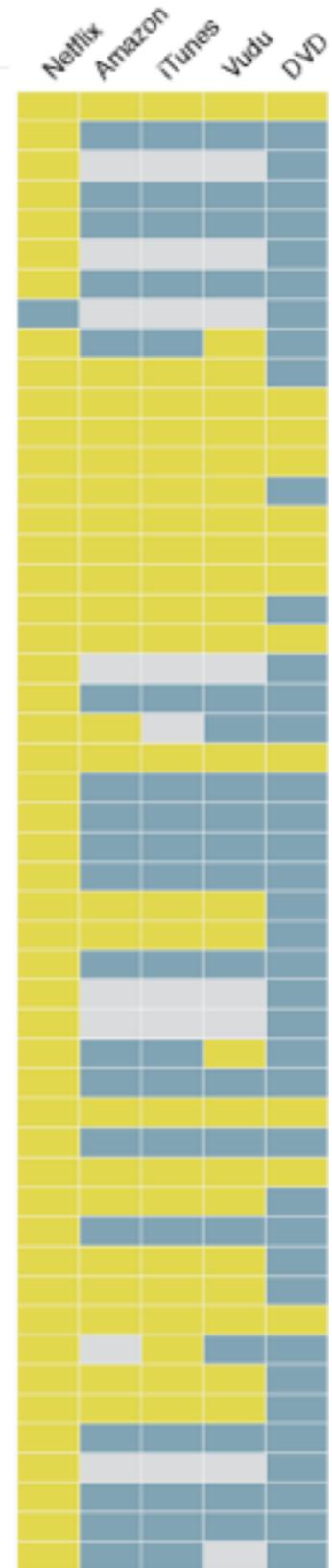
1-50

- 1 Harry Potter and the Deathly Hallows Part 2
- 2 Transformers: Dark of the Moon
- 3 The Twilight Saga: Breaking Dawn Part 1
- 4 The Hangover Part II
- 5 Pirates of the Caribbean: On Stranger Tides
- 6 Fast Five
- 7 Cars 2
- 8 Thor
- 9 Rise of the Planet of the Apes
- 10 Captain America: The First Avenger
- 11 The Help
- 12 Bridesmaids
- 13 Kung Fu Panda 2
- 14 X-Men: First Class
- 15 Puss in Boots
- 16 Rio
- 17 The Smurfs
- 18 Mission: Impossible — Ghost Protocol
- 19 Sherlock Holmes: A Game of Shadows
- 20 Super 8
- 21 Rango
- 22 Horrible Bosses
- 23 Green Lantern
- 24 Hop
- 25 Paranormal Activity 3
- 26 Just Go With It
- 27 Bad Teacher
- 28 Cowboys & Aliens
- 29 Gnomeo and Juliet
- 30 The Green Hornet
- 31 Alvin and the Chipmunks: Chipwrecked
- 32 The Lion King (in 3D)
- 33 Real Steel
- 34 Crazy, Stupid, Love.
- 35 The Muppets
- 36 Battle: Los Angeles
- 37 Immortals
- 38 Zookeeper
- 39 Limitless
- 40 Tower Heist
- 41 Contagion
- 42 Moneyball
- 43 Justin Bieber: Never Say Never
- 44 Dolphin Tale
- 45 Jack and Jill
- 46 No Strings Attached
- 47 Mr. Popper's Penguins
- 48 Unknown
- 49 The Adjustment Bureau
- 50 Happy Feet Two



51-100

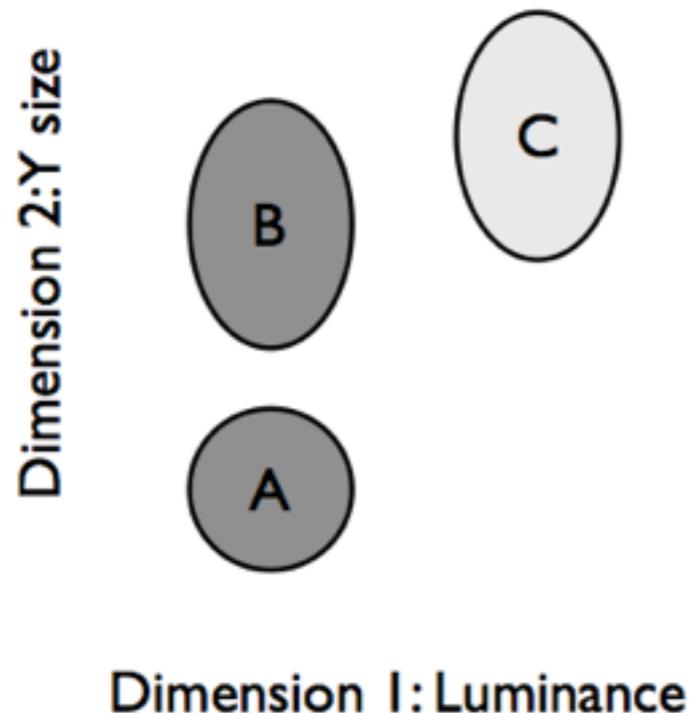
- 51 The Girl with the Dragon Tattoo (2011)
- 52 Water for Elephants
- 53 The Lincoln Lawyer
- 54 Midnight in Paris
- 55 Friends with Benefits
- 56 I Am Number Four
- 57 Source Code
- 58 Insidious
- 59 Tyler Perry's Madea's Big Happy Family
- 60 Diary of a Wimpy Kid: Rodrick Rules
- 61 Footloose (2011)
- 62 The Adventures of Tintin
- 63 Hugo
- 64 The Dilemma
- 65 New Year's Eve
- 66 Arthur Christmas
- 67 War Horse
- 68 Hall Pass
- 69 We Bought a Zoo
- 70 Soul Surfer
- 71 Final Destination 5
- 72 The Ides of March
- 73 The Descendants
- 74 Hanna
- 75 Something Borrowed
- 76 Spy Kids: All the Time in the World
- 77 Scream 4
- 78 Big Mommas: Like Father, Like Son
- 79 Red Riding Hood
- 80 Paul
- 81 The Roommate
- 82 Jumping the Broom
- 83 The Change-Up
- 84 30 Minutes or Less
- 85 In Time
- 86 Colombiana
- 87 J. Edgar
- 88 Sucker Punch
- 89 Larry Crowne
- 90 50/50
- 91 Drive (2011)
- 92 A Very Harold & Kumar 3D Christmas
- 93 Courageous
- 94 The Rite
- 95 Arthur (2011)
- 96 The Debt
- 97 Priest
- 98 The Mechanic
- 99 Abduction
- 100 Beastly



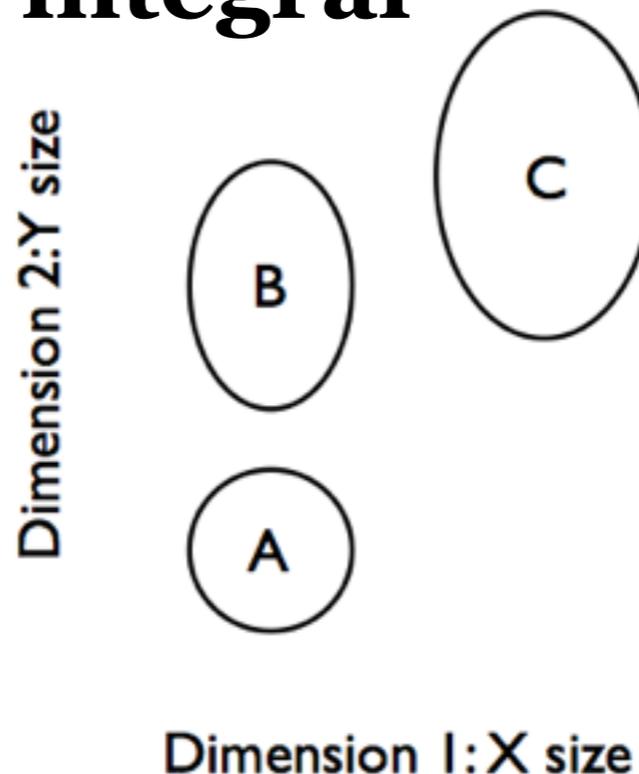
SEPARABLE vs INTEGRAL

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

separable



integral



SEPARABLE vs INTEGRAL

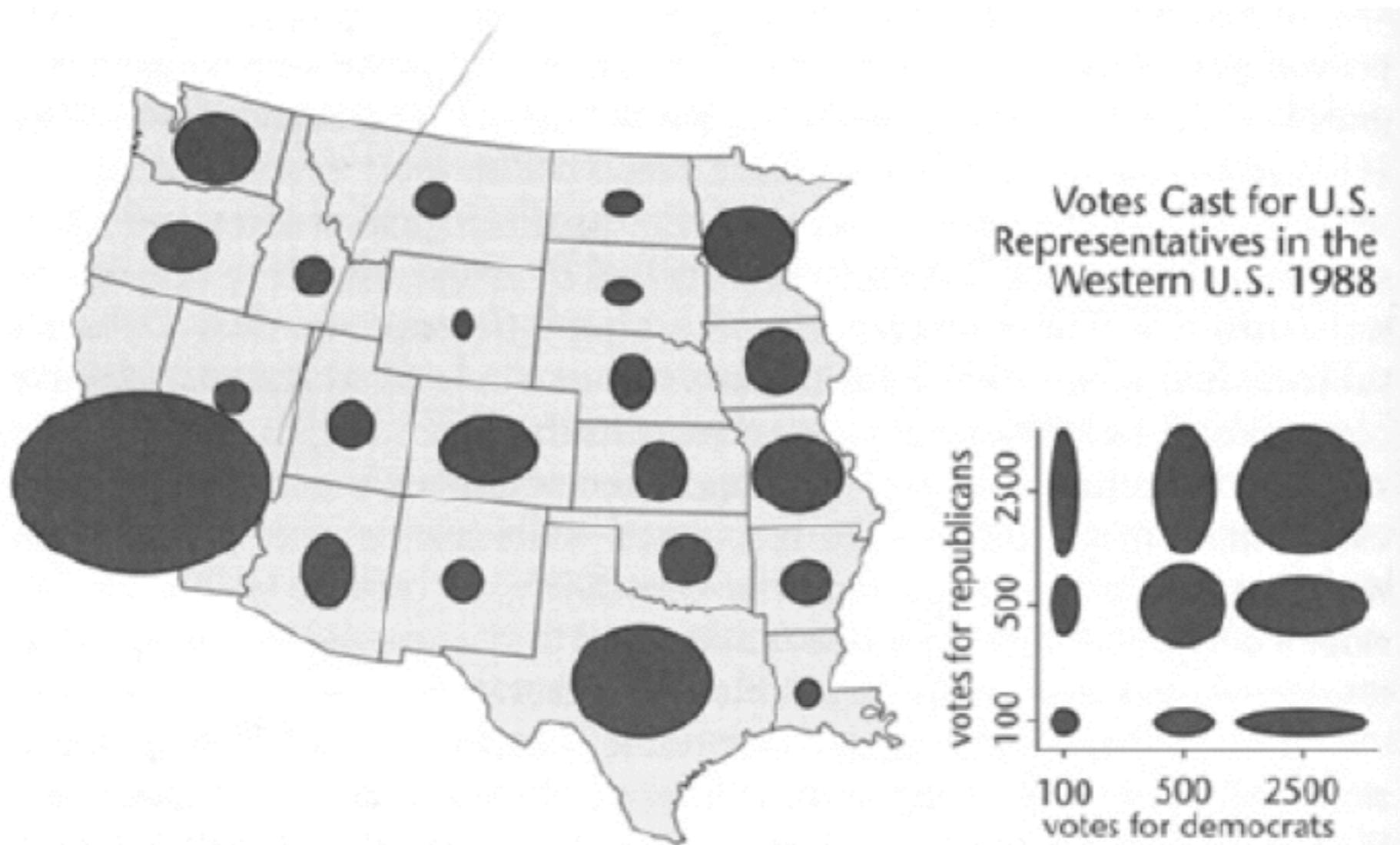


FIGURE 3.38. An example of the use of an ellipse as a map symbol in which the horizontal and vertical axes represent different (but presumably related) variables.

SEPARABLE vs INTEGRAL

separable ←————→ integral



color | location

color | motion

color | shape

size | orientation

x-size | y-size

red-green | yellow-blue

READING, WRITING, AND EARNING MONEY

The latest data from the U.S. Census's American Community Survey paints a fascinating picture of the United States at the county level. We've looked at the educational achievement and the median income of the entire nation, to see where people are going to school, where they're earning money, and if there is any correlation.



A HIGH SCHOOL GRADUATES 65% 75% 82% 90%



B COLLEGE GRADUATES 15% 25% 30% 40%

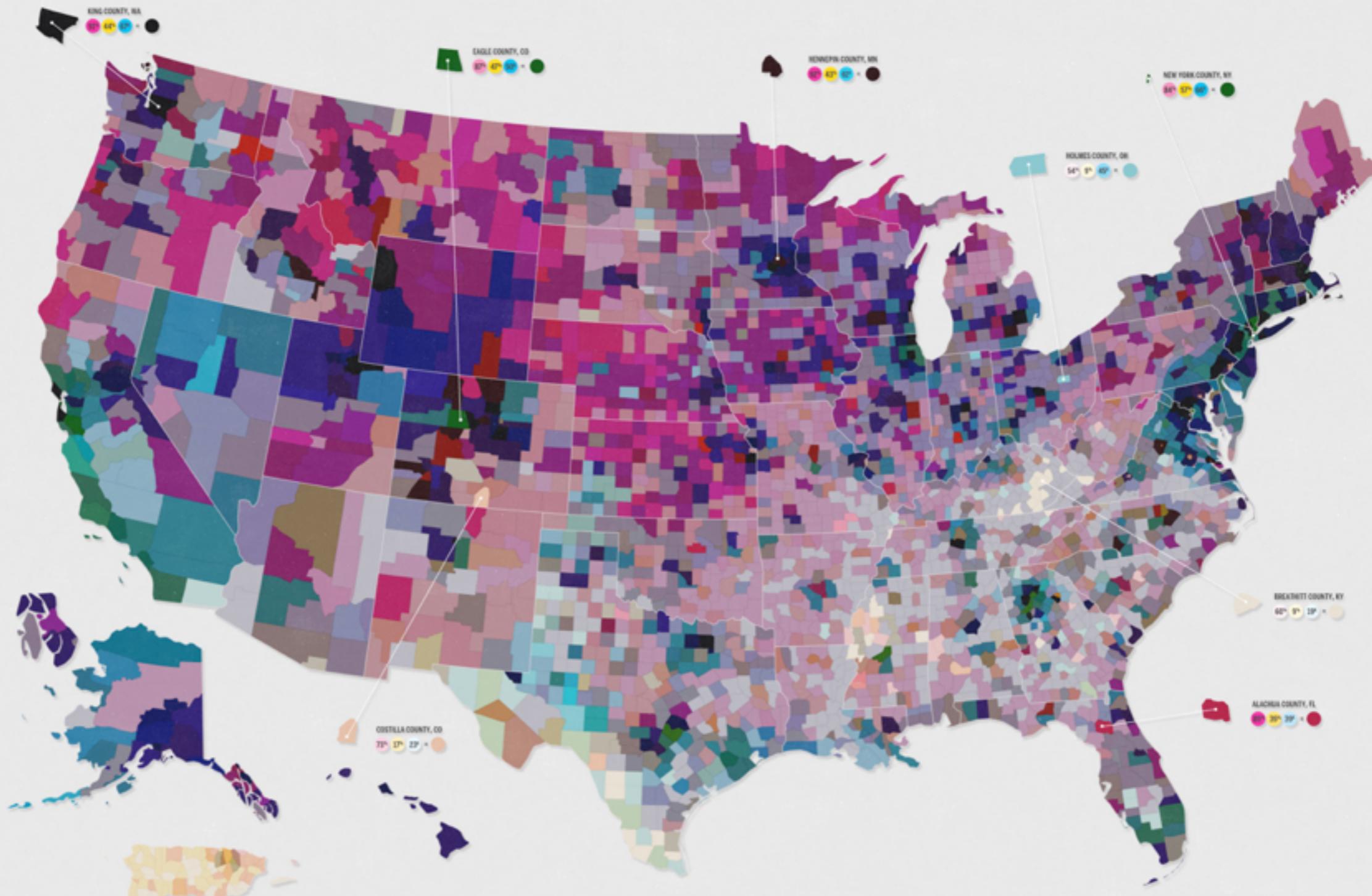


C MEDIAN HOUSEHOLD INCOME 25K 40K 50K 60K

The map at right is a product of overlaying the three sets of data. The variation in hue and value has been produced from the data shown above. In general, darker counties represent a more educated, better paid population while lighter areas represent communities with fewer graduates and lower incomes.



A collaboration between GOOD and Gregory Muehler
SOURCE: US Census



encoding semantics

Graphical Code		Semantics
Small shapes defined by closed contour, texture, color, shaded solid.		Object, idea, entity, node.
Spatially ordered graphical objects.		Related information or a sequence. In a sequence the left-to-right ordering convention borrows from the western convention for written language.
Graphical objects in proximity.		Similar concepts, related information.
Graphical objects having the same shape, color, or texture.		Similar concepts, related information.
Size of graphical object Height of graphical object.		Magnitude, quantity, importance.
Shapes connected by contour.		Related entities, path between entities.
Thickness of connecting contour.		Strength of relationship.
Color and texture of connecting contour.		Type of relationship.
Shapes enclosed by a contour, or a common texture, or a common color.		Contained entities. Related entities.
Nested regions, partitioned regions.		Hierarchical concepts.
Attached shapes.		Parts of a conceptual structure.

+ *perceptual effects we talked about last week*

- pop-out
- Stevens power law
- Weber's law
- Gestalt principles

-marks and channels

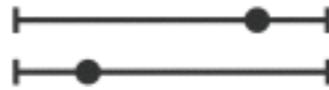
-planar position

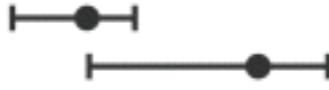
-time

-color

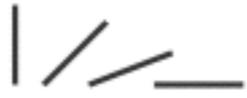
WHAT'S SO SPECIAL ABOUT THE PLANE?

➔ **Magnitude Channels: Ordered Attributes**

Position on common scale 

Position on unaligned scale 

Length (1D size) 

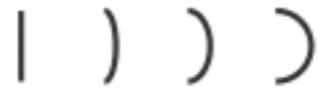
Tilt/angle 

Area (2D size) 

Depth (3D position) 

Color luminance 

Color saturation 

Curvature 

Volume (3D size) 

Same Same

Most Effectiveness Least

➔ **Identity Channels: Categorical Attributes**

Spatial region 

Color hue 

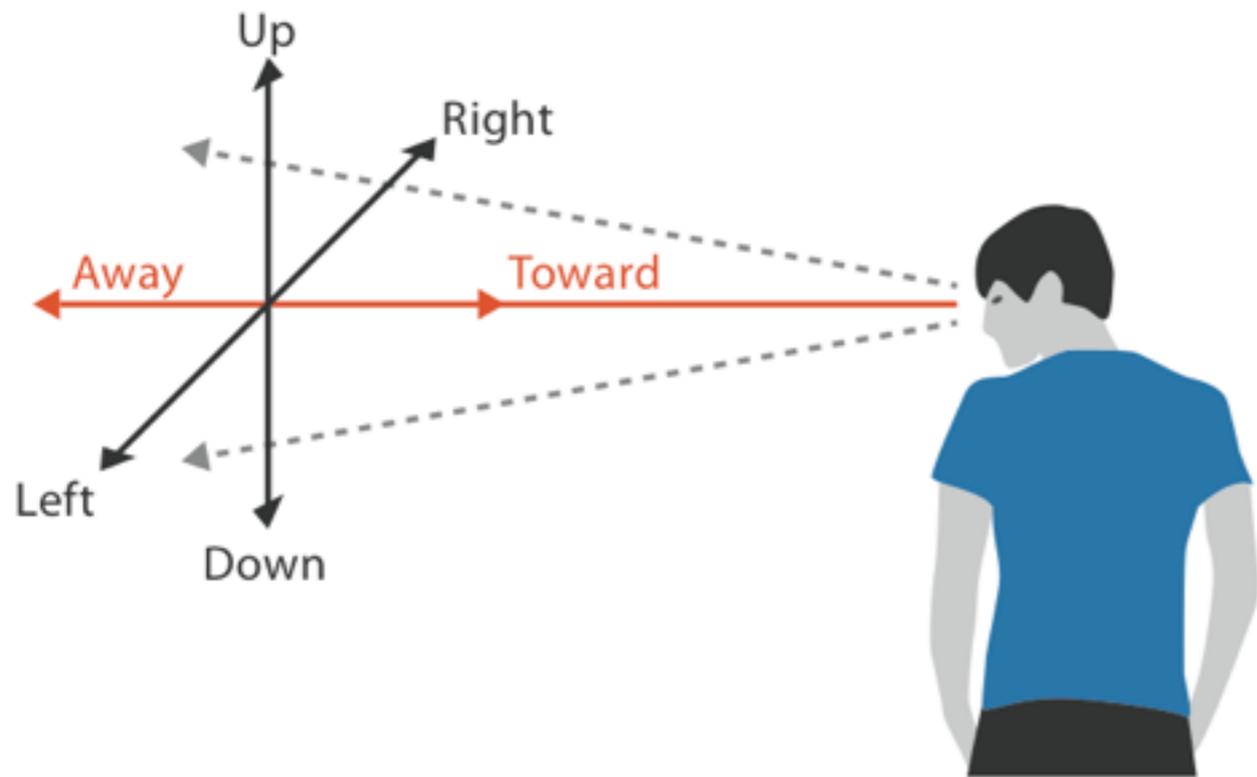
Motion 

Shape 

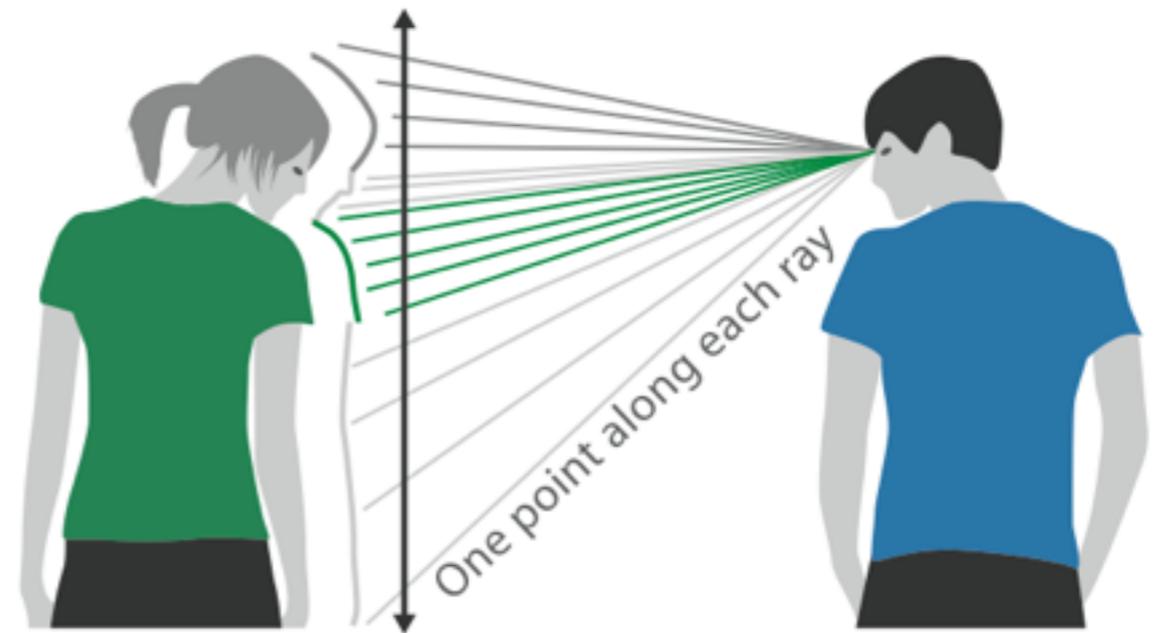
we see the world as a 2.5D space

we see the world as a ~~2.5D~~ ^{2.05D} space

we see the world as a ~~2.5D~~ ^{2.05D} space



Thousands of points up/down and left/right



We can only see the outside shell of the world

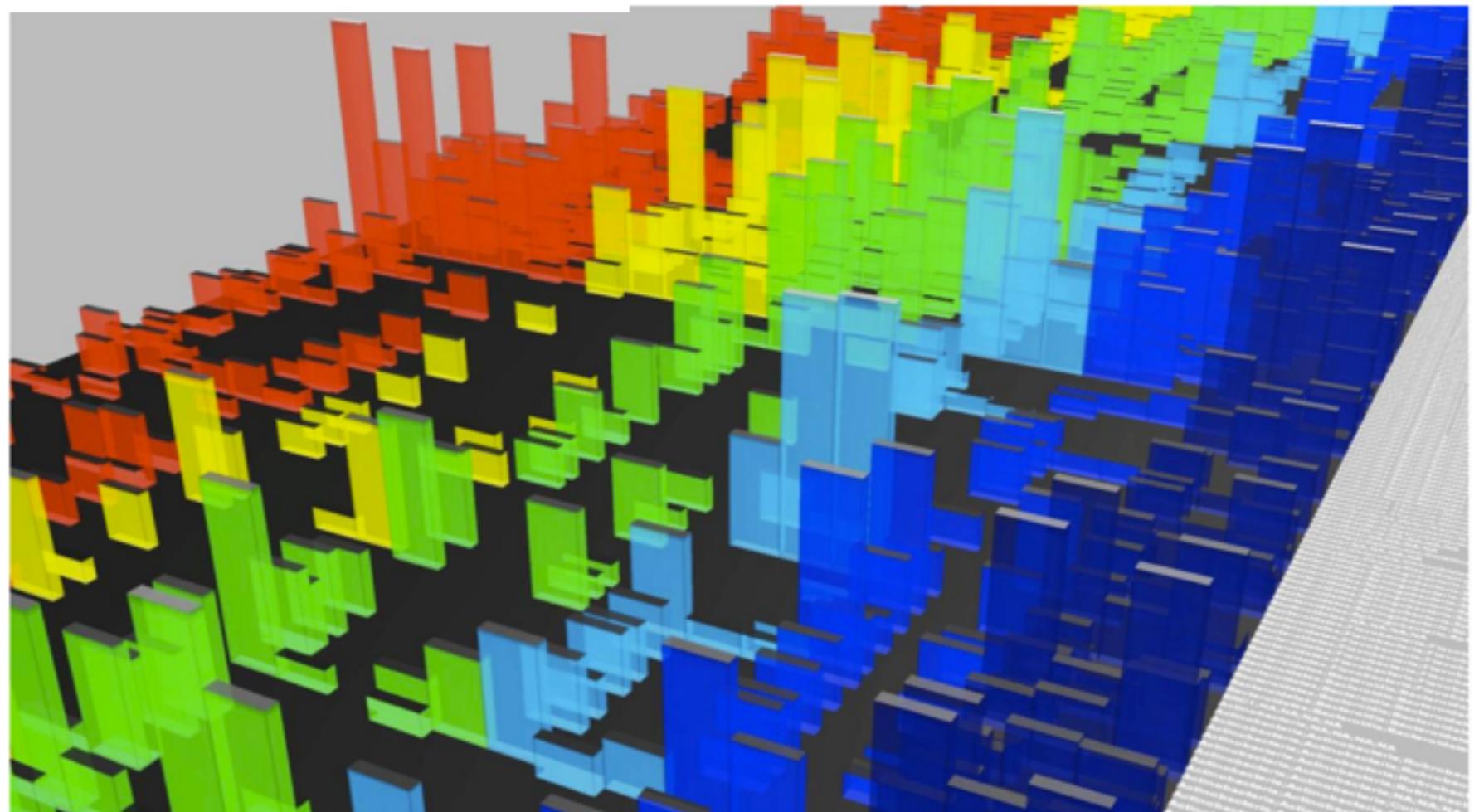
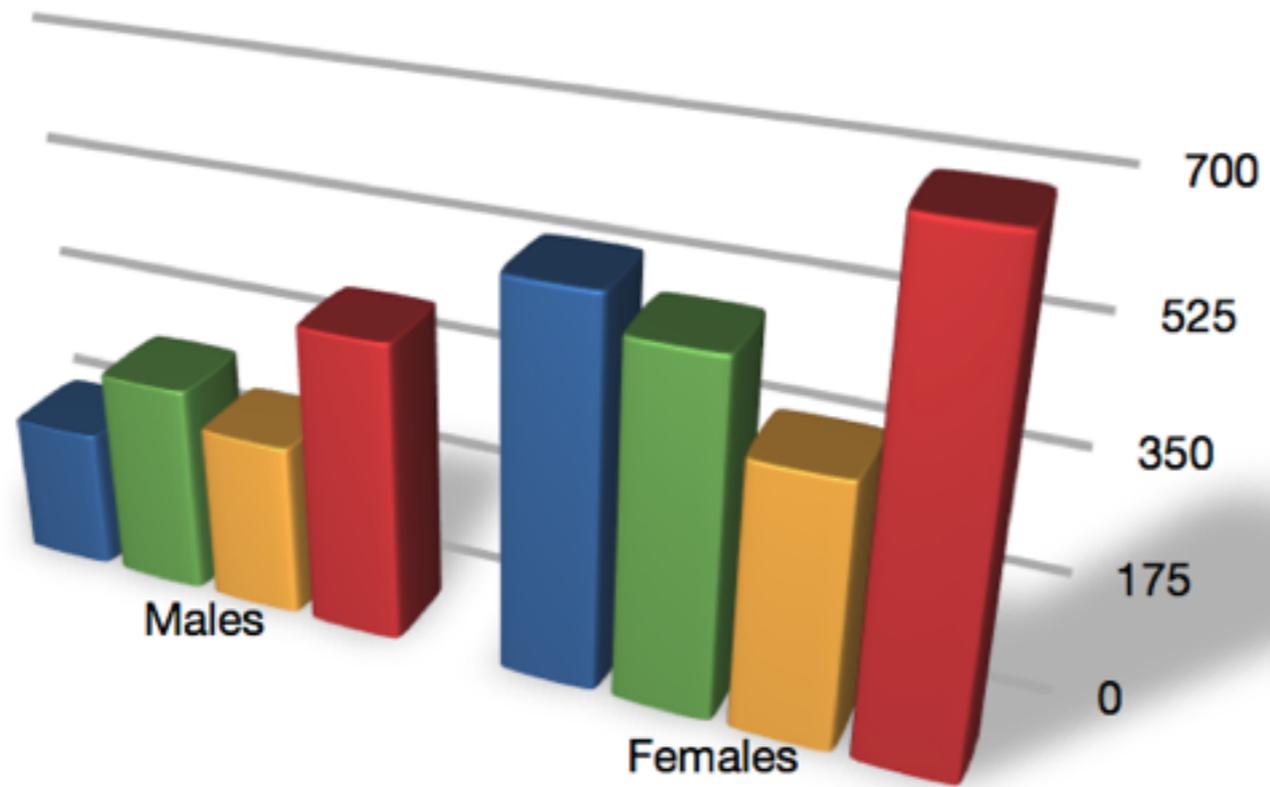
- **power does not extend to 3D**

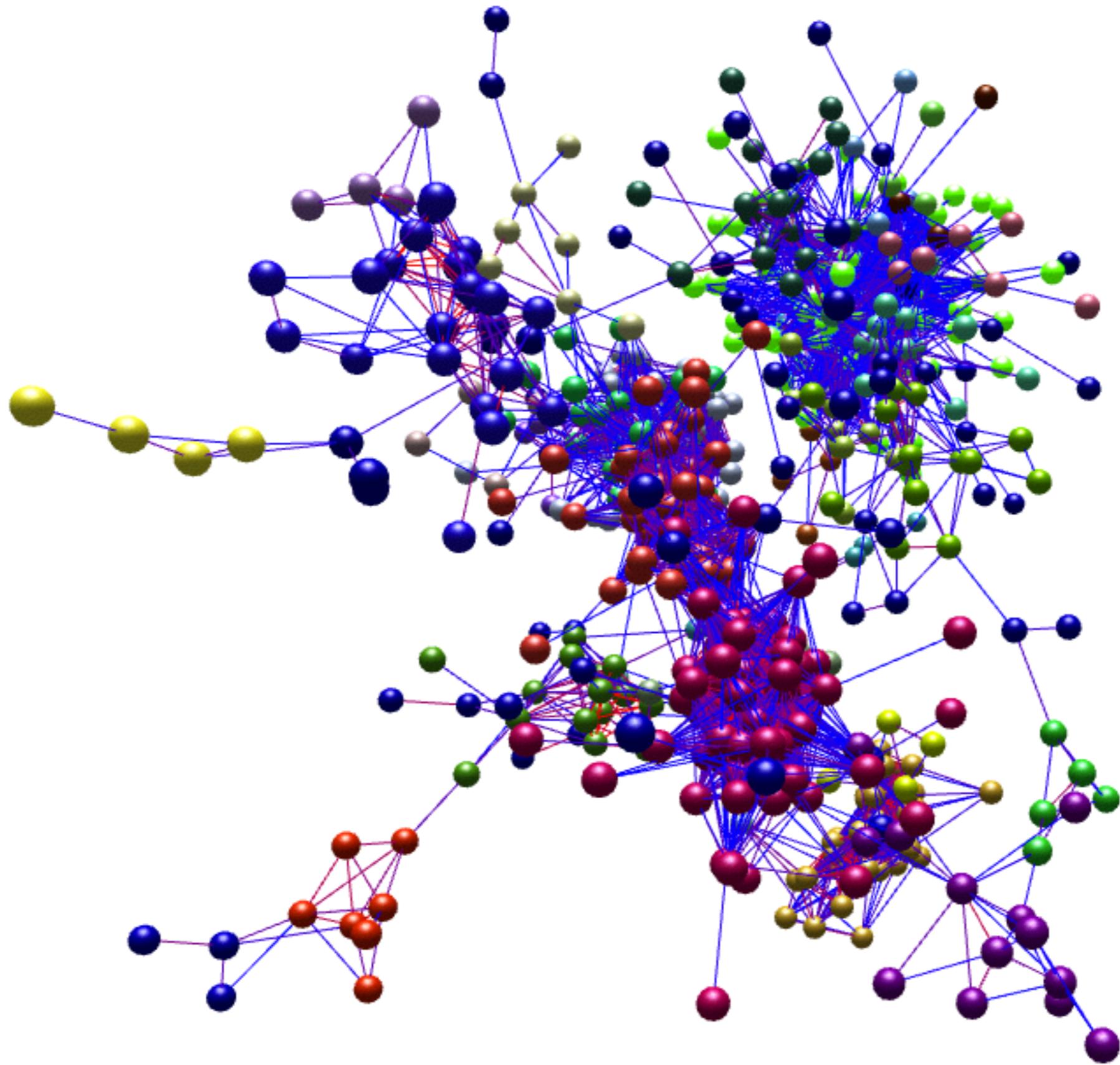
- perspective cues

- *interfere with color and size channels*

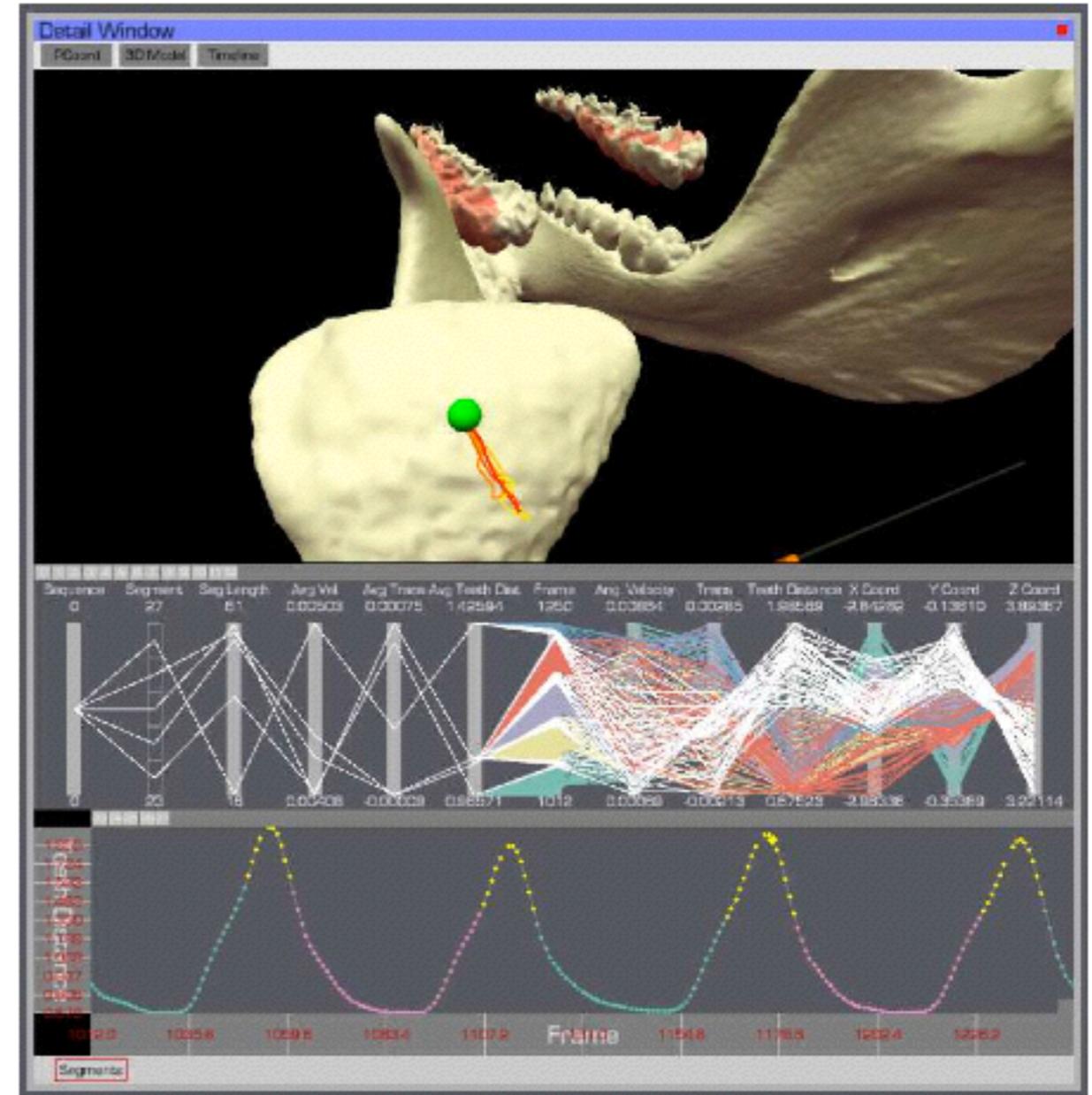
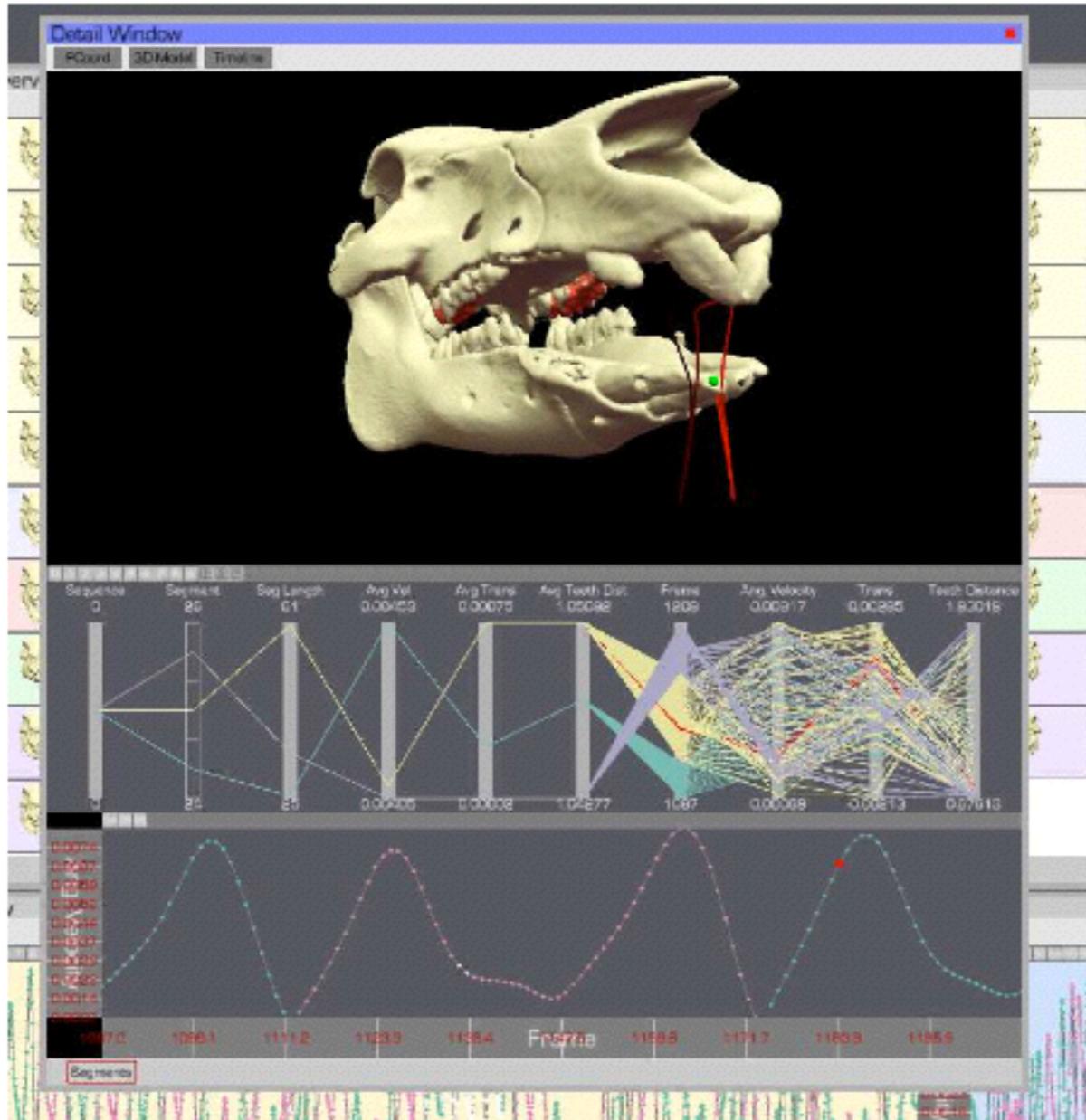
- occlusion of data

- text legibility





2D and 3D?



-marks and channels

-planar position

-time

-color

visualization

1. uses perception to point out interesting things.
2. uses pictures to enhance working memory.

TIME AS ENCODING CHANNEL

- **external versus internal memory**
 - *easy to compare views by moving eyes*
 - *hard to compare view to memory of what you saw*

ComParrot
by Bonnie J. Malcolm

Can you spot 12 differences between these pictures?



www.comparrotpuzzles.com © 2001 Bonnie J. Malcolm

ComParrot
by Bonnie J. Malcolm

Can you spot 12 differences between these pictures?



ComParrot

by Bonnie J. Malcolm

Can you spot 12 differences between these pictures?



www.comparrotpuzzles.com © 2001 Bonnie J. Malcolm



Solution: 1. Top tree leaf removed. 2. Nose line on left giraffe removed. 3. Shadow on lower left coconut removed. 4. Leaf vein below monkey removed. 5. Ear line on left giraffe removed. 6. Bottom spot on right giraffe removed. 7. Small leaf at right of tree colored in. 8. Horn on right giraffe moved. 9. Spot on left giraffe moved. 10. Branch on left giraffe moved. 11. Gecko tail longer. 12. Gecko eye missing.

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Animation: can it facilitate?

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Graphics have been used since ancient times to portray things that are inherently spatiovisual, like maps and buildings. More recently, graphics have been used to portray things that are metaphorically spatiovisual, like graphs and organizational

RECOMMENDED READING

charts. The assumption is that graphics can facilitate comprehension, learning, memory, communication and inference. Assumptions aside, research on static graphics has shown that only carefully designed and appropriate graphics prove to be beneficial for conveying complex systems. Effective graphics conform to the Congruence Principle according to which the content and format of the graphic should correspond to the content and format of the concepts to be conveyed. From this, it follows that animated graphics should be effective in portraying change over time. Yet the research on the

WHEN TO USE ANIMATION?

GOOD: STORYTELLING

Hans Rosling shows the best stats you've ever seen | Video on TED.com

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

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Hans Rosling shows the best stats you've ever seen

TED2006, Filmed Feb 2006; Posted Jun 2006



3,471,109 Views  33k

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You've never seen data presented like this. With the drama and urgency of a sportscaster, statistics guru Hans Rosling debunks myths about the so-called "developing world."

 THE ROLEX ARTS INITIATIVE PAIRS ESTABLISHED MENTORS WITH EMERGING PROTÉGÉS FOR A YEAR OF CREATIVE COLLABORATION

00:17 | 19:53 **Share** **Rate**

WHAT TO WATCH NEXT

Hans Rosling's new insights on

GOOD: TRANSITIONS



GOOD: TRANSITIONS



BAD: COMPARING COMPLEX STATE CHANGES OVER TIME

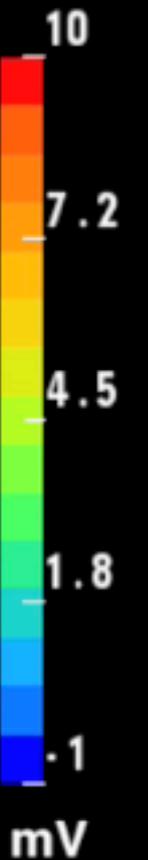
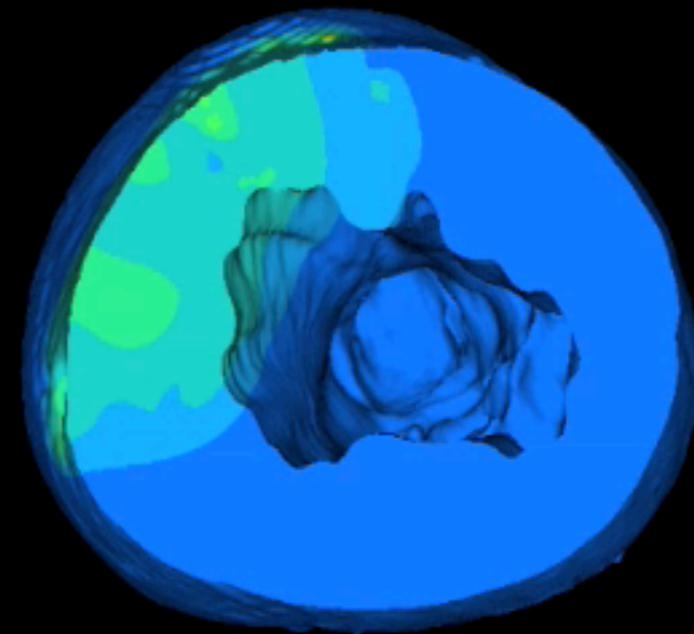
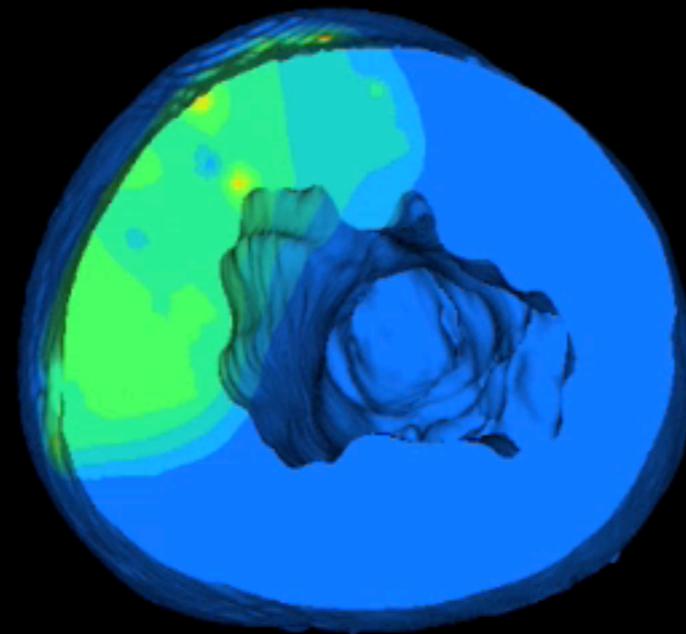
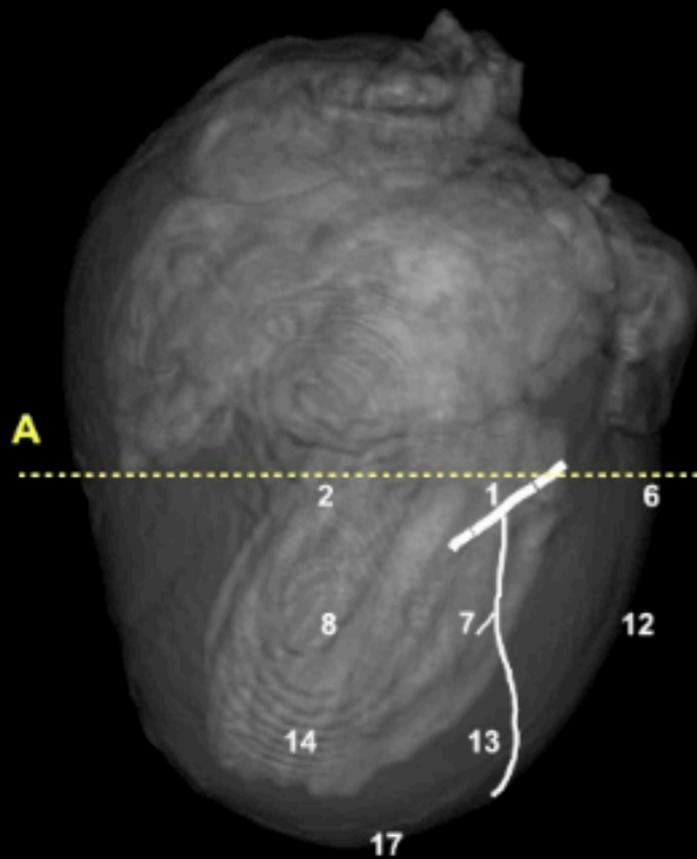
RSM-09-11-03 Canine In Situ Model

Progression of ST Elevated Regions (ST 40)

Axial Plane A

Demand

Supply



Flow Rate: 35ml

Pacing Rate: 400ms

Occlusion Cycle: 15

BAD: COMPARING COMPLEX STATE CHANGES OVER TIME

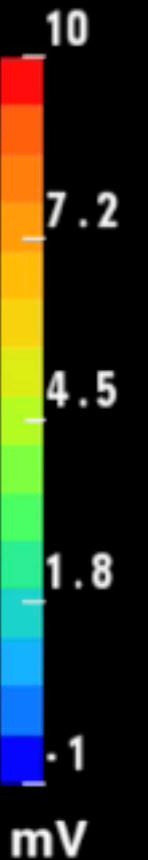
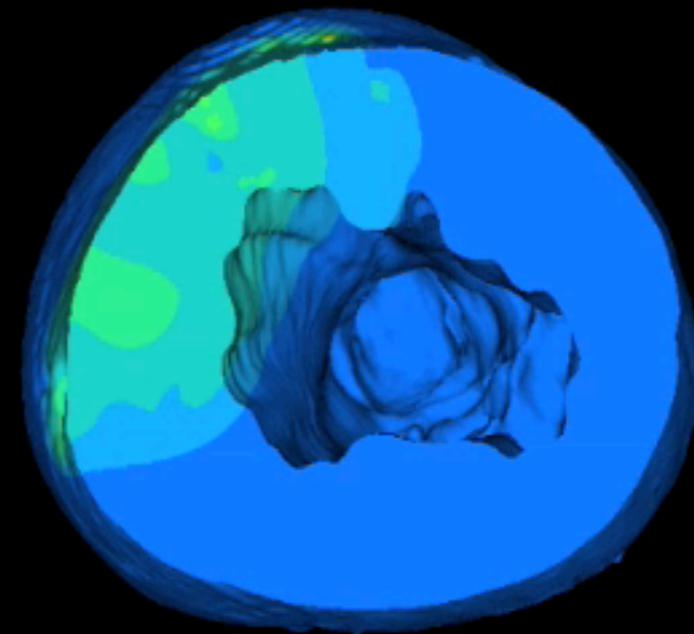
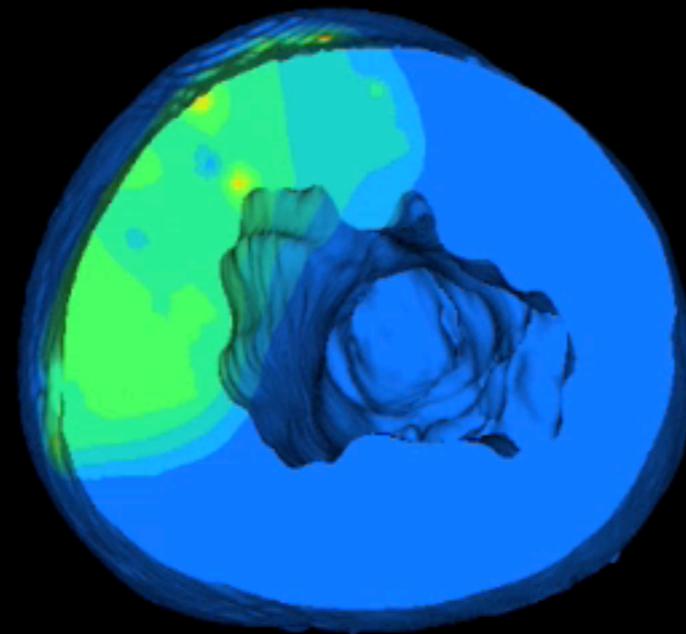
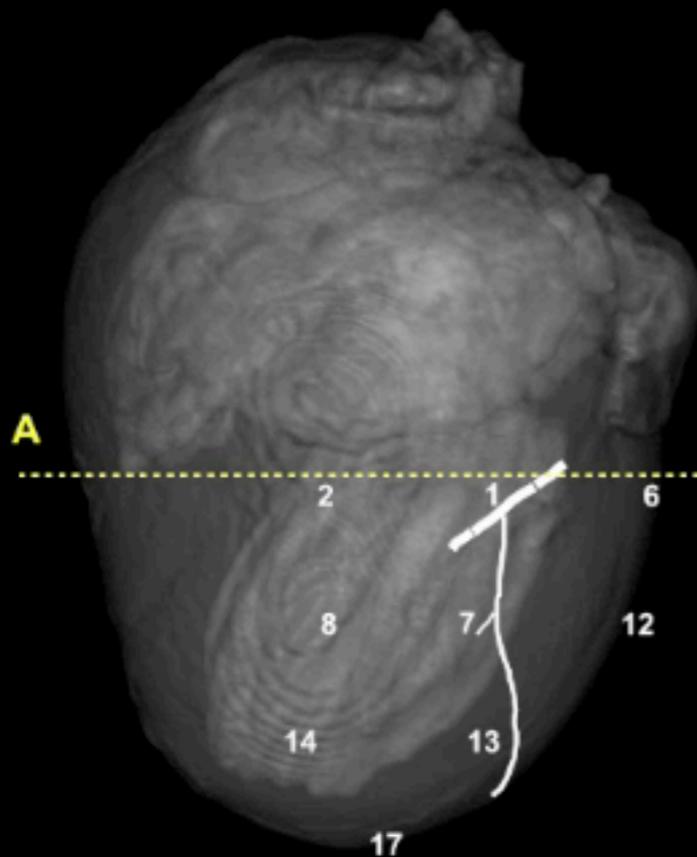
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Progression of ST Elevated Regions (ST 40)

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Supply

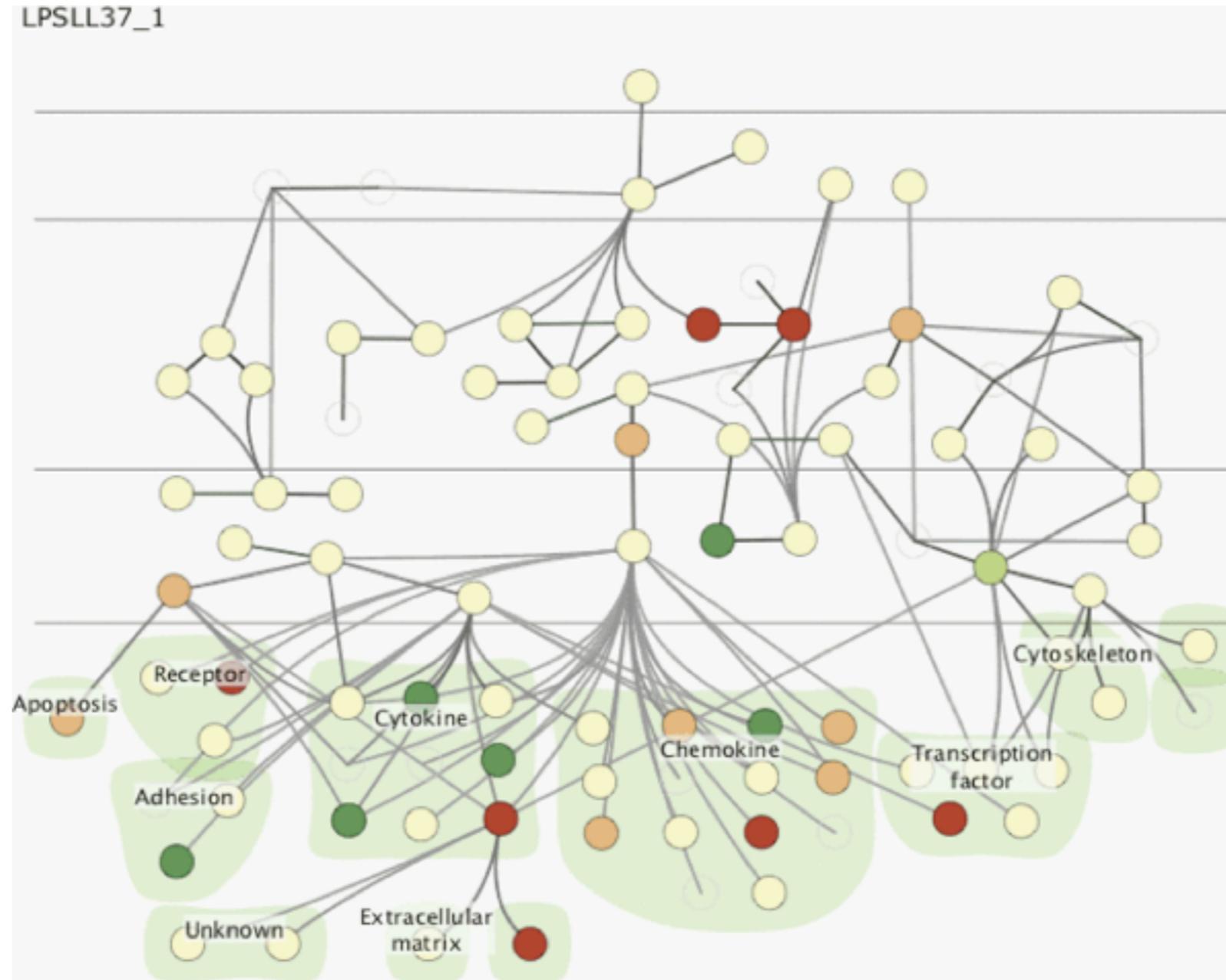


Flow Rate: 35ml

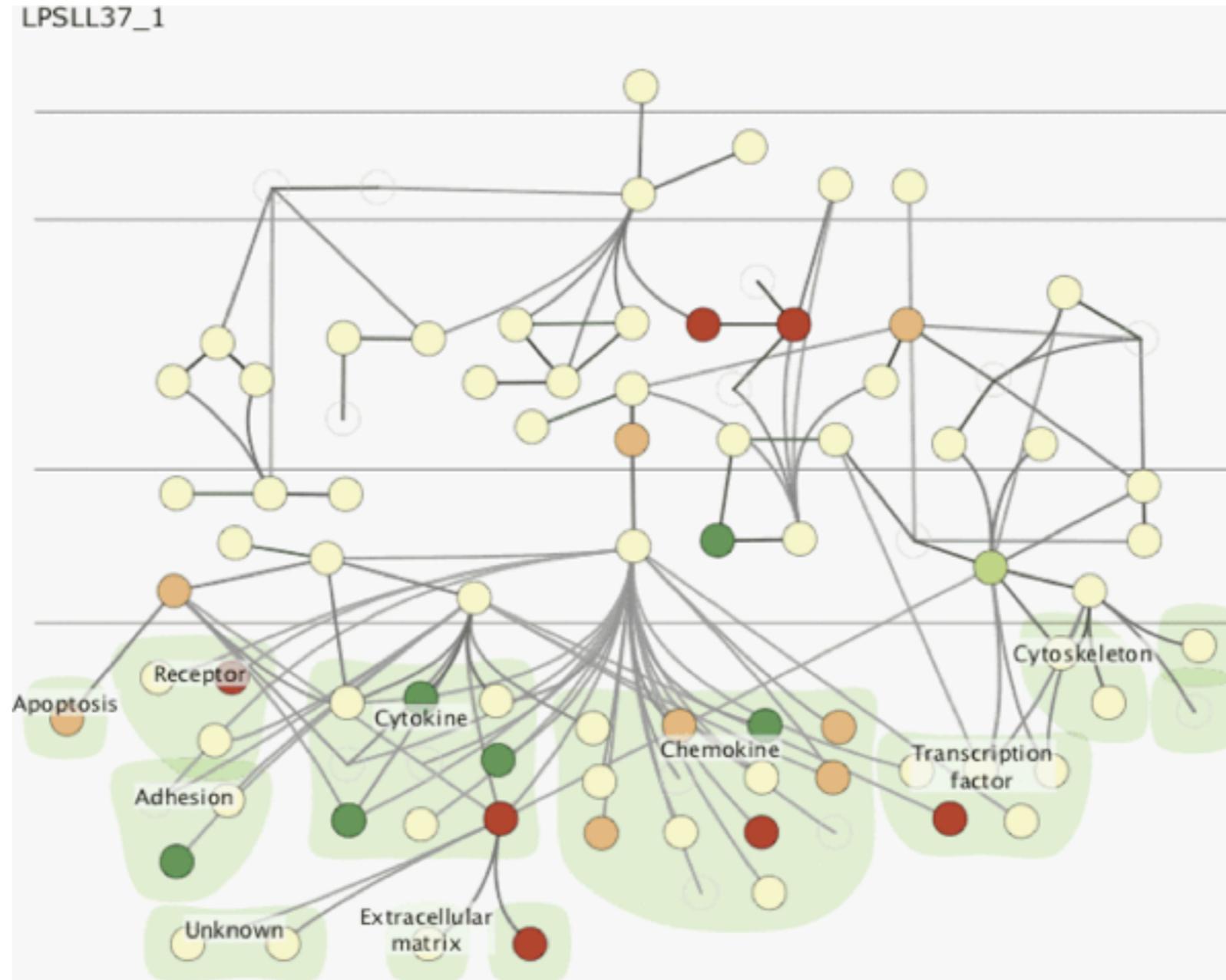
Pacing Rate: 400ms

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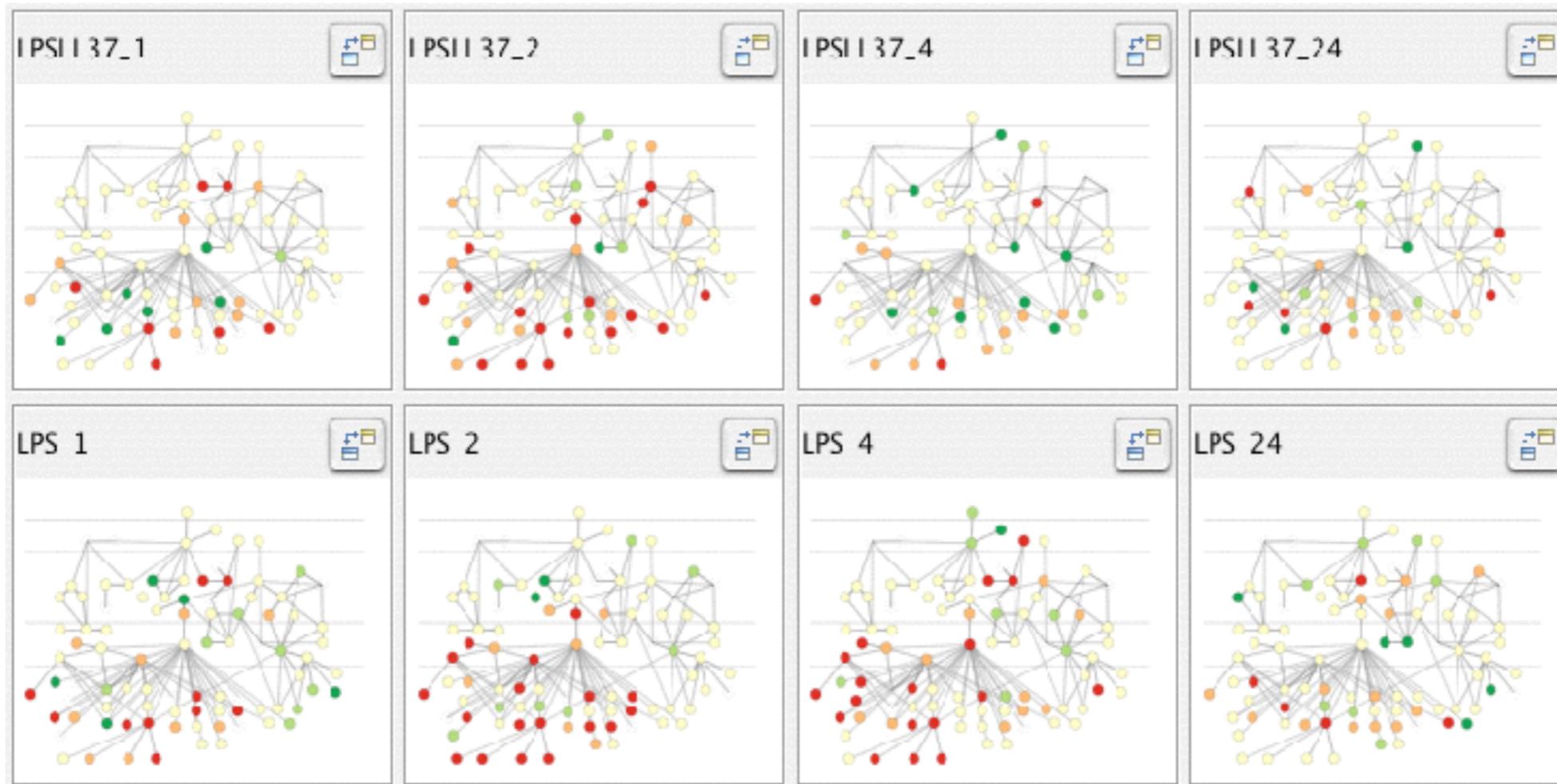
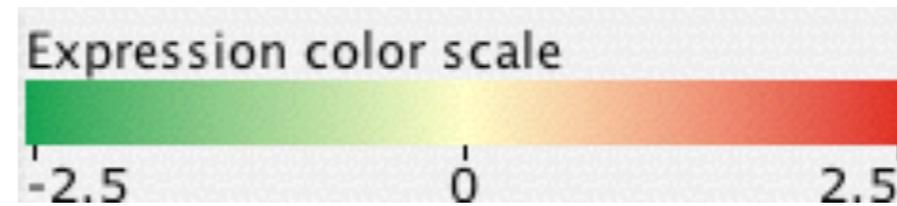
BAD: MULTIPLE STATES WITH MULTIPLE CHANGES



BAD: MULTIPLE STATES WITH MULTIPLE CHANGES



BAD: MULTIPLE STATES WITH MULTIPLE CHANGES **alternative: small multiples**



-marks and channels

-planar position

-time

-color

Get it right in black and white.
Maureen Stone

L6. Color

REQUIRED READING

Chapter 10

Map Color and Other Channels

10.1 The Big Picture

This chapter covers the mapping of color and other nonspatial channels in visual encoding design choices, summarized in Figure 10.1. The colloquial term *color* is best understood in terms of three separate channels: luminance, hue, and saturation. The major design choice for colormap construction is whether the intent is to distinguish between categorical attributes or to encode ordered attributes. Sequential ordered colormaps show a progression of an attribute from a minimum to a maximum value, while diverging ordered colormaps have a visual indication of a zero point in the center where the attribute values diverge to negative on one side and positive on the other. Bivariate colormaps are designed to show two attributes simultaneously using carefully designed combinations of luminance, hue, and saturation.

The characteristics of several more channels are also covered: the magnitude channels of size, angle, and curvature and the identity channels of shape and motion.

10.2 Color Theory

Chapter 4

Color

Most large animals have worse color vision than humans. Color vision is of little benefit to grass eaters like zebras and cows—these animals have only two dimensions of color vision. The motion of a tiger's prey is more critical than its color, and although cats, like grazing animals, have the physiological basis for two dimensions of color, it is extremely difficult to train them to respond to color. For the most part, they behave as if they



Color vision makes it much easier to see the fruit of the West African Akee tree.