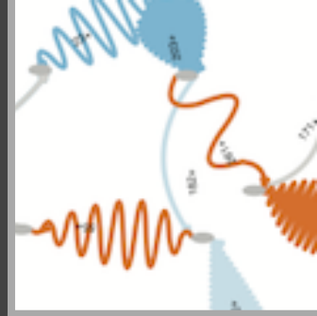
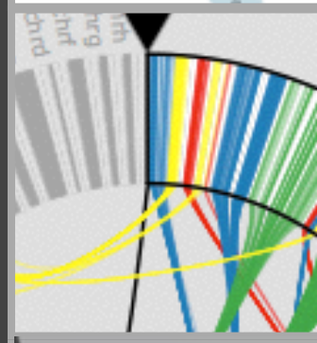
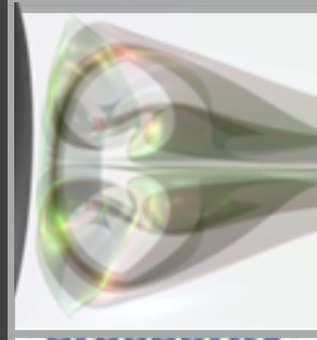
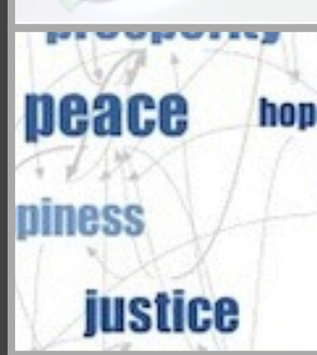
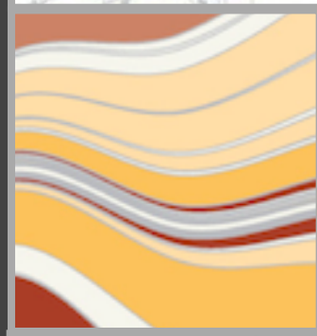
cs6630 | September 9 2014

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

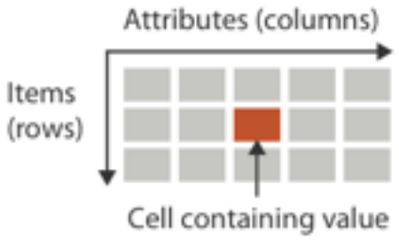
type vs *semantics*

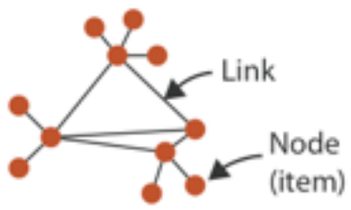
data types

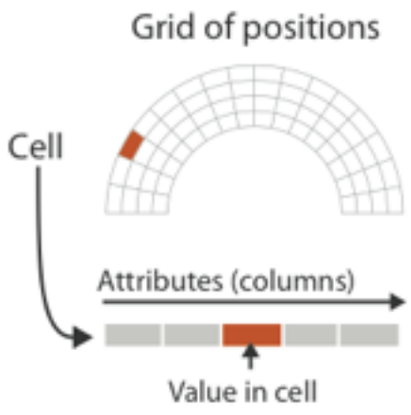
- Items
- Attributes
- Links
- Positions
- Grids

dataset types

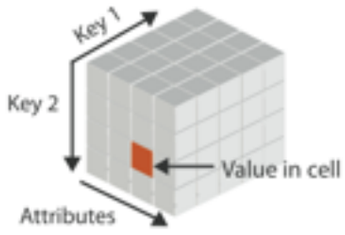
Tables	Networks & Trees	Fields	Geometry	Clusters, Sets, Lists
Items	Items (nodes)	Grids	Items	Items
Attributes	Links	Positions	Positions	
	Attributes	Attributes		







→ *Multidimensional Table*



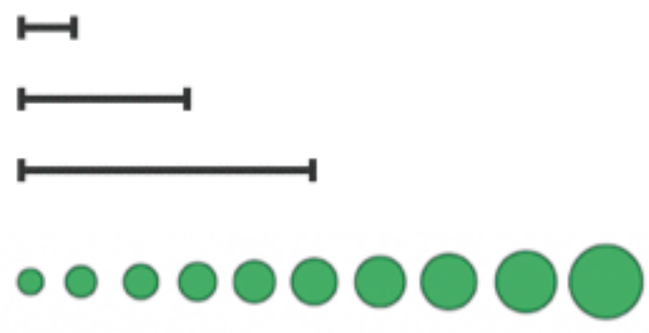
→ *Trees*

attribute types

- Categorical
  no implicit ordering

- Ordered
  - *Ordinal*

  - *Quantitative*
    meaningful magnitude, can do arithmetic



- Sequential

- Diverging

- Cyclic

- Hierarchical

special

attribute semantics

key *vs* value

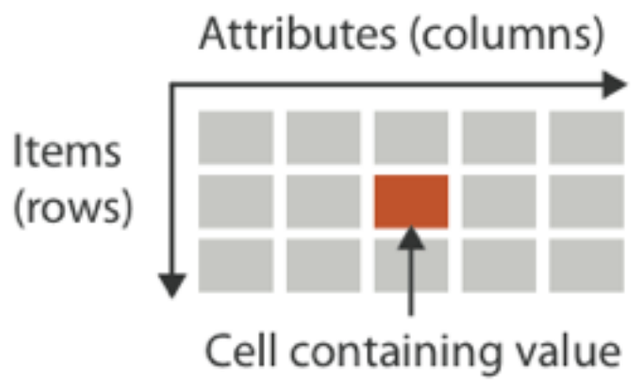
special

attribute semantics

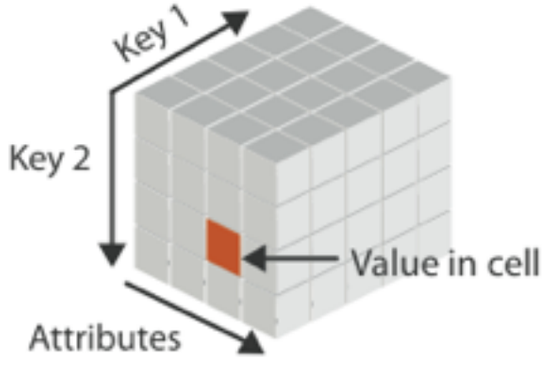
key *vs* value

tables

flat



multidimensional



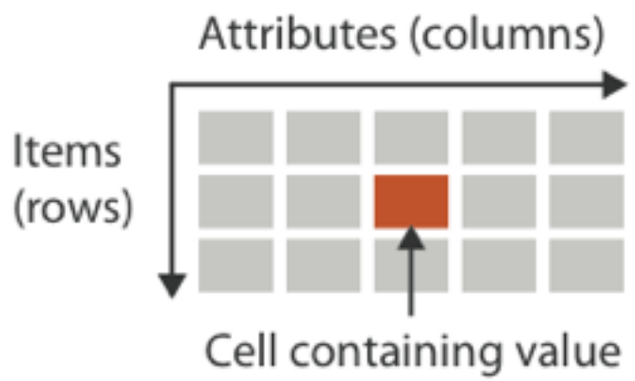
special

attribute semantics

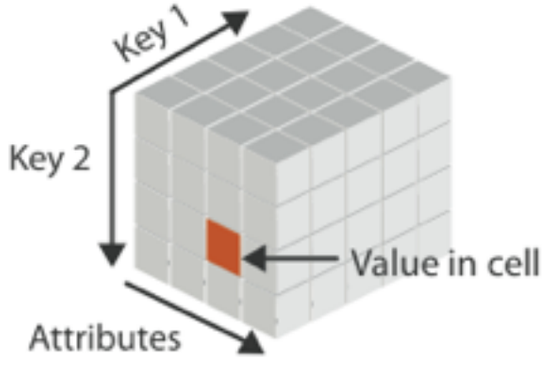
key *vs* value

tables

flat

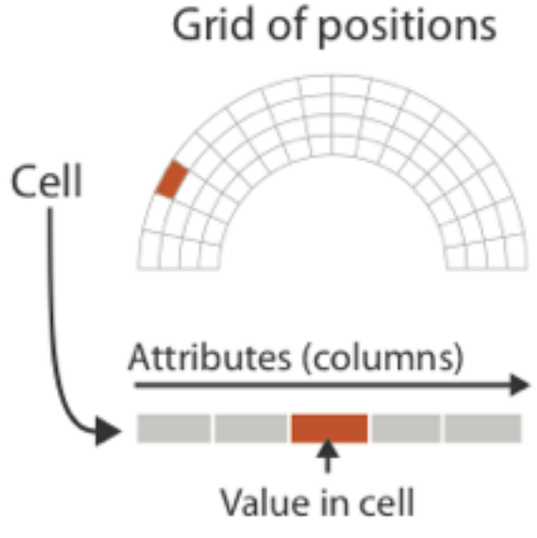


multidimensional



fields

Grid of positions



special

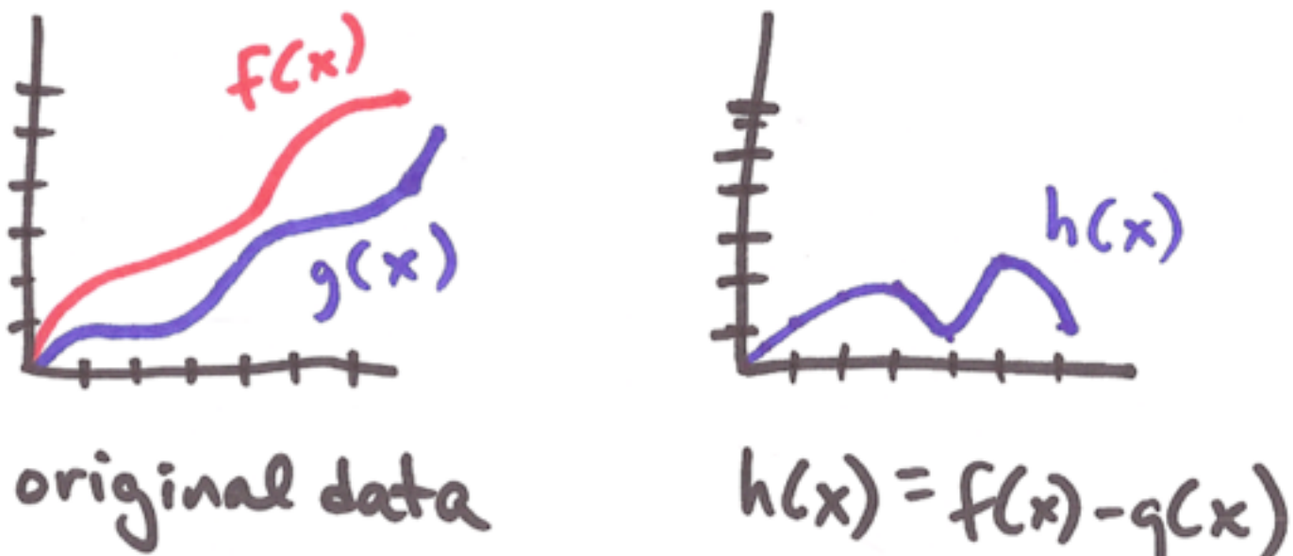
attribute semantics

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

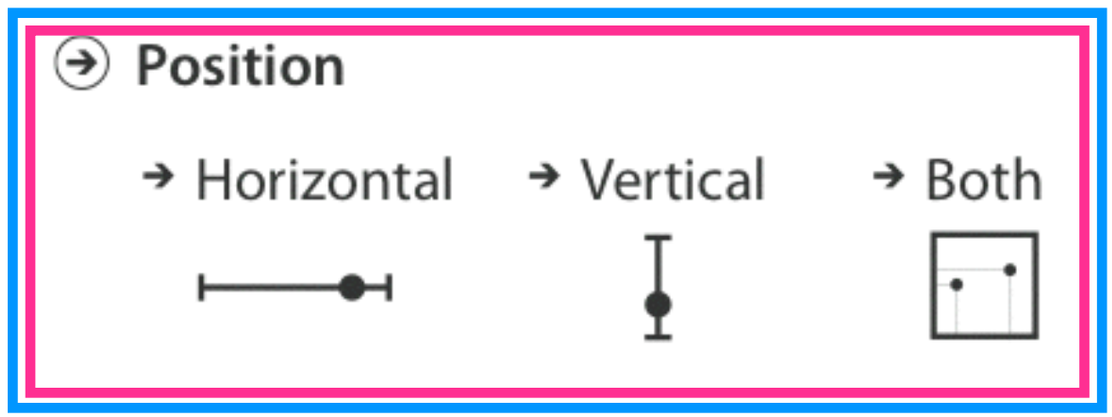
Tilt

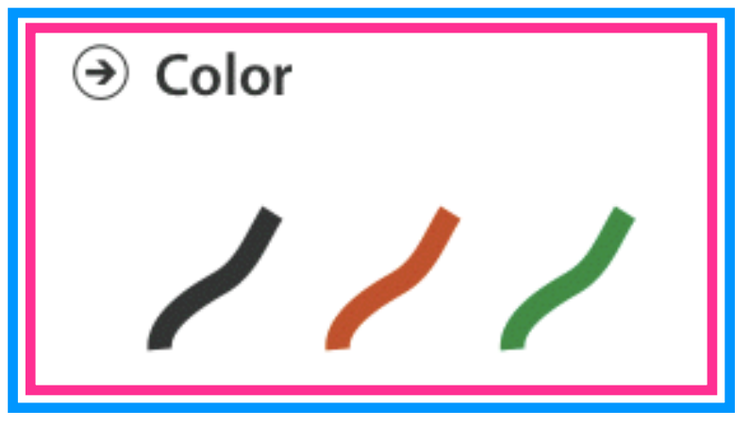
Size

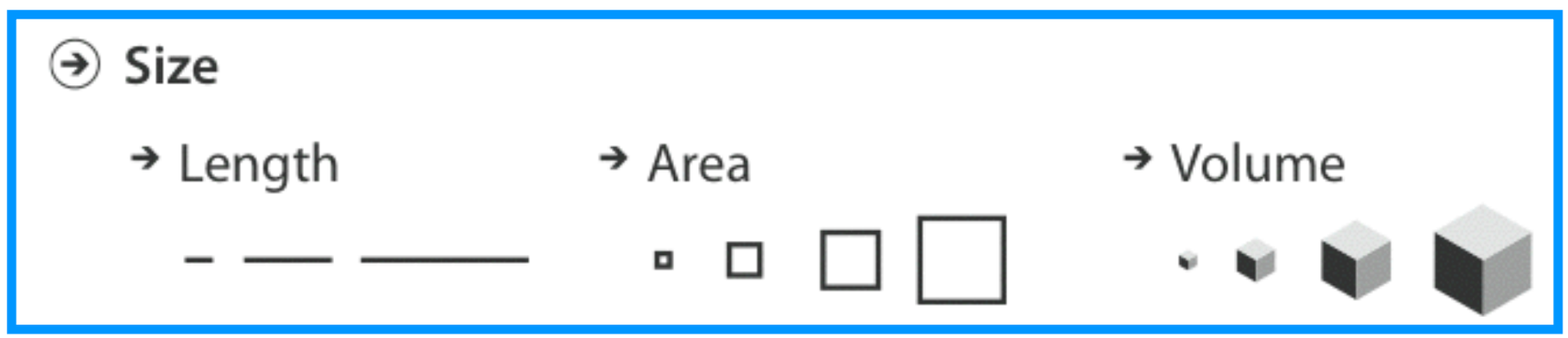
- Length
- Area
- Volume

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)

Most

Same

Same

Least

Effectiveness

Identity Channels: Categorical Attributes

Spatial region

Color hue

Motion

Shape

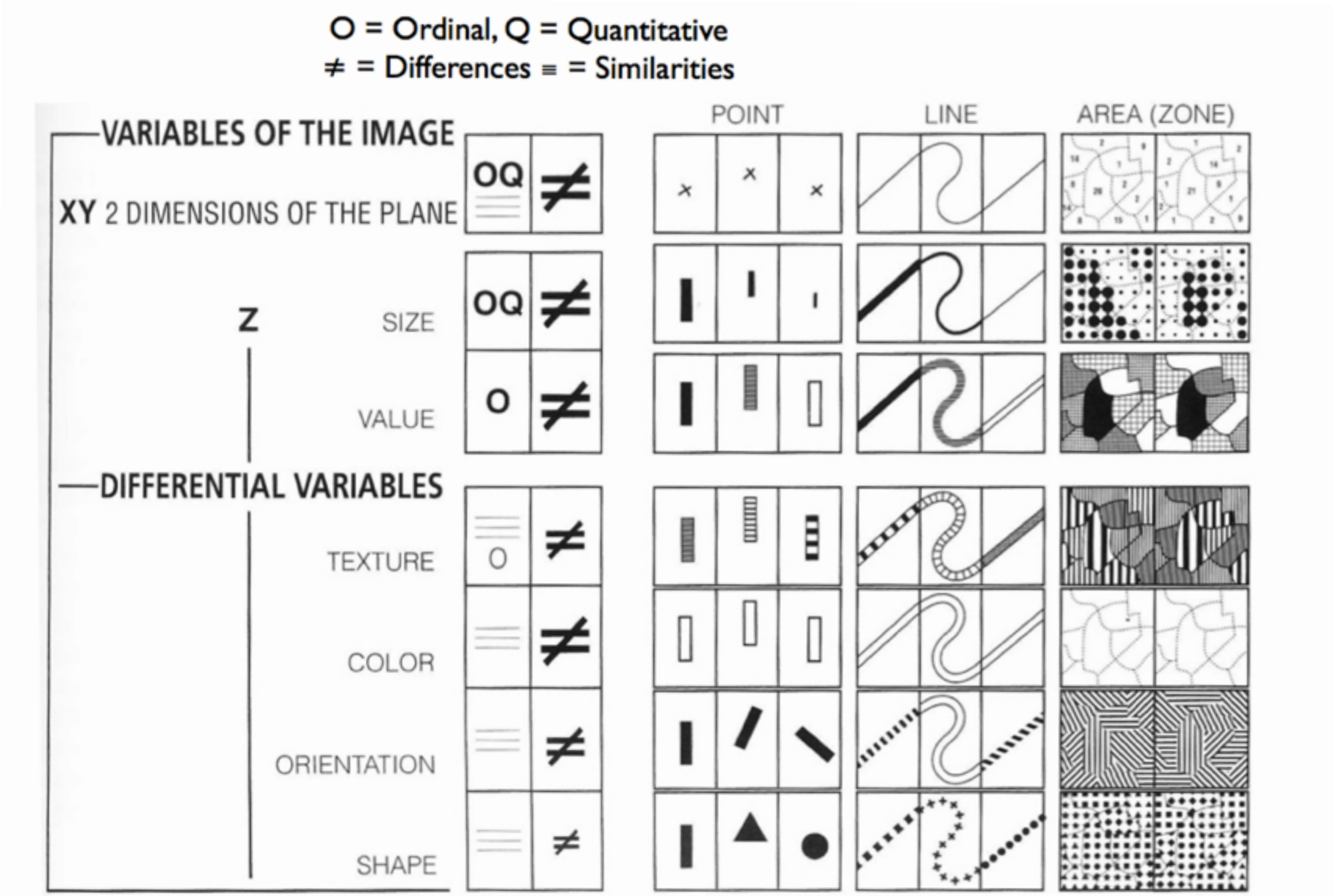
effectiveness

name that channel . . .

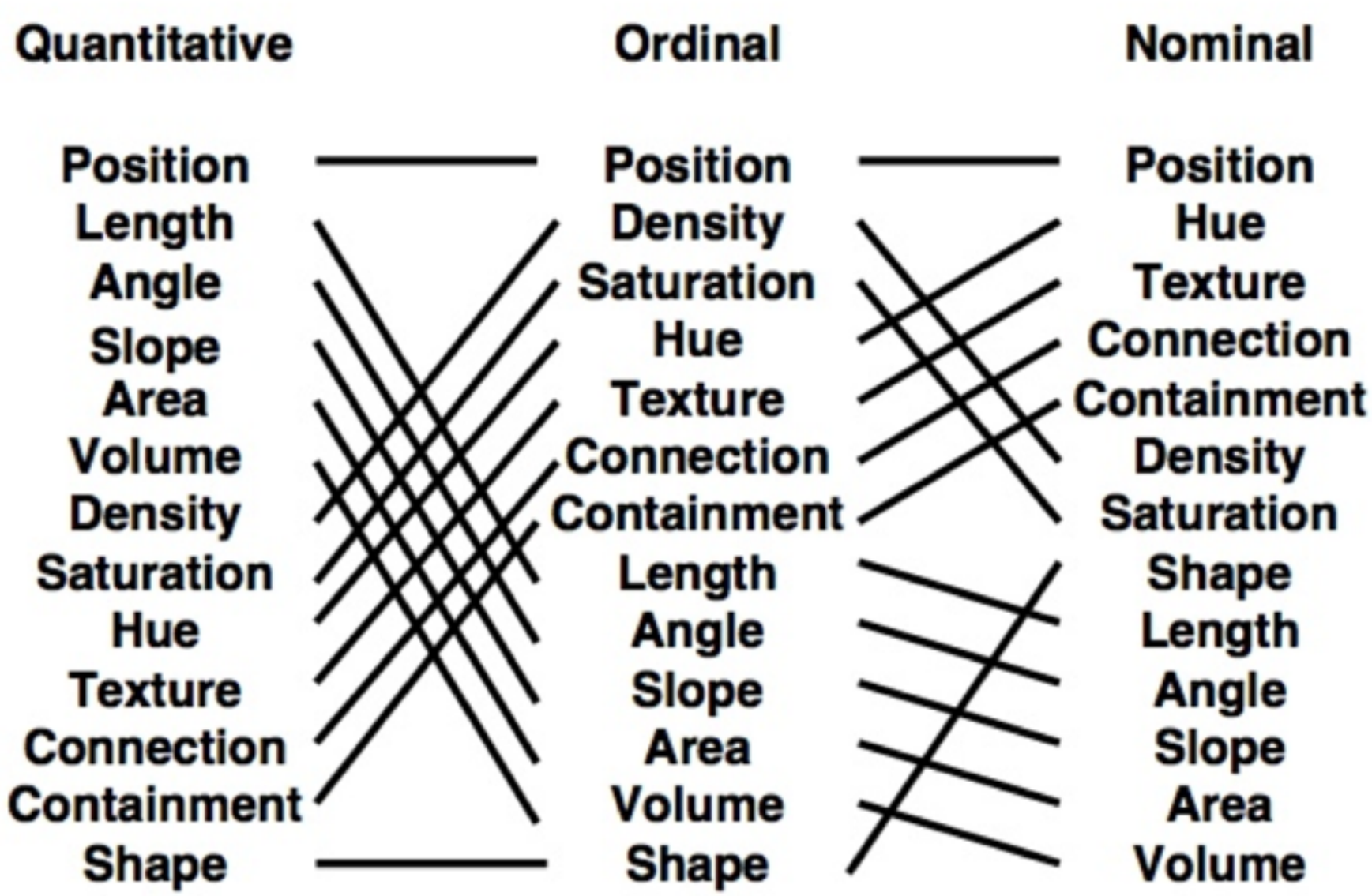

Projected concentration after 50 more years of unrestricted fossil fuel burning
Today's CO_2 concentration
650,000 Years of CO_2 and Temperature
CO_2 (ppmv)
400
350
300
250
200
600,000
500,000
400,000
300,000
200,000
100,000
0
Temp. in F°

WHERE DO RANKINGS COME FROM?

Bertin, 1967


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

Mackinlay, 1986



Cleveland & McGill, 1984

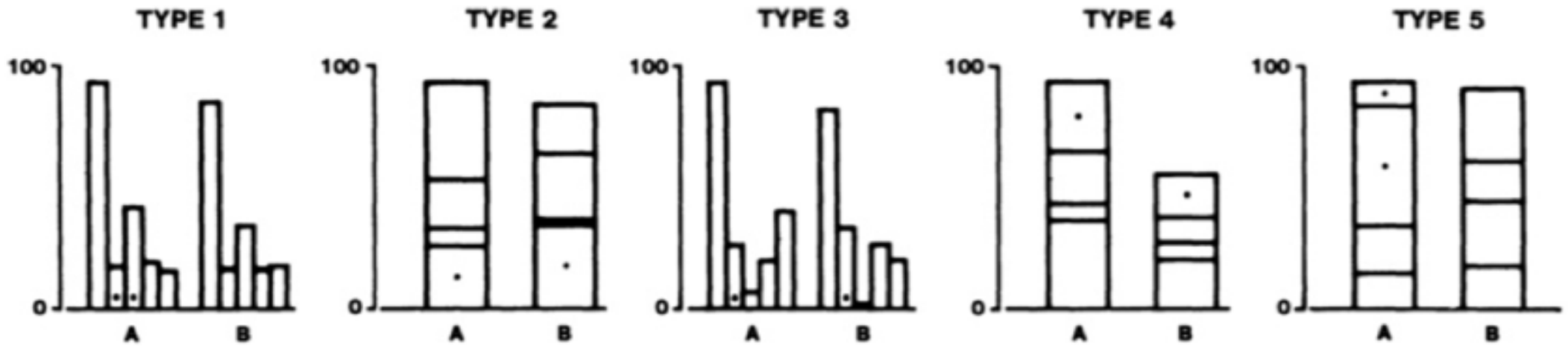


Figure 4. Graphs from position–length experiment.

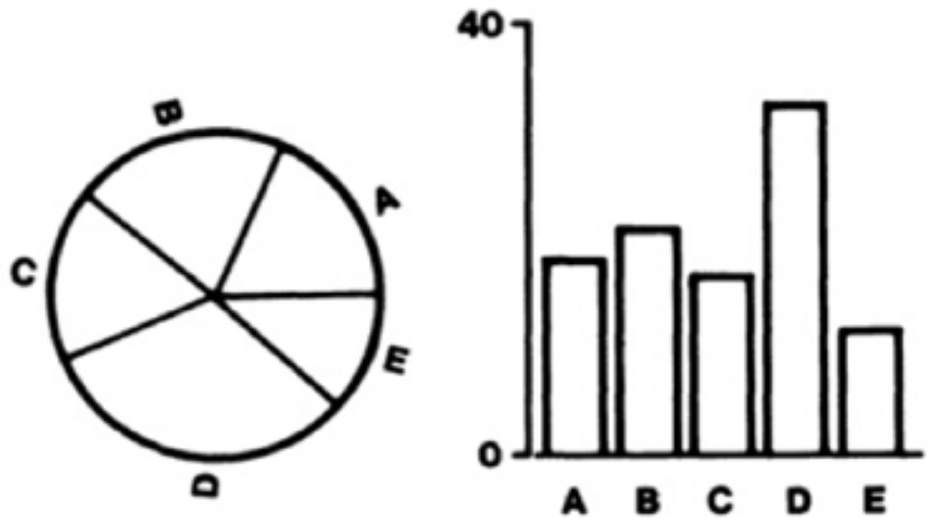


Figure 3. Graphs from position–angle experiment.

Heer & Bostock, 2010

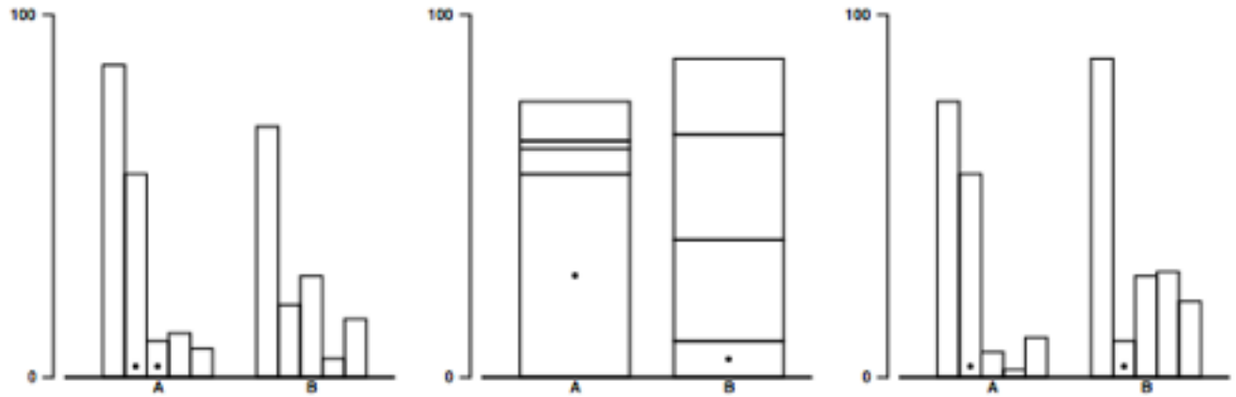


Figure 1: Stimuli for judgment tasks T1, T2 & T3. Subjects estimated percent differences between elements.

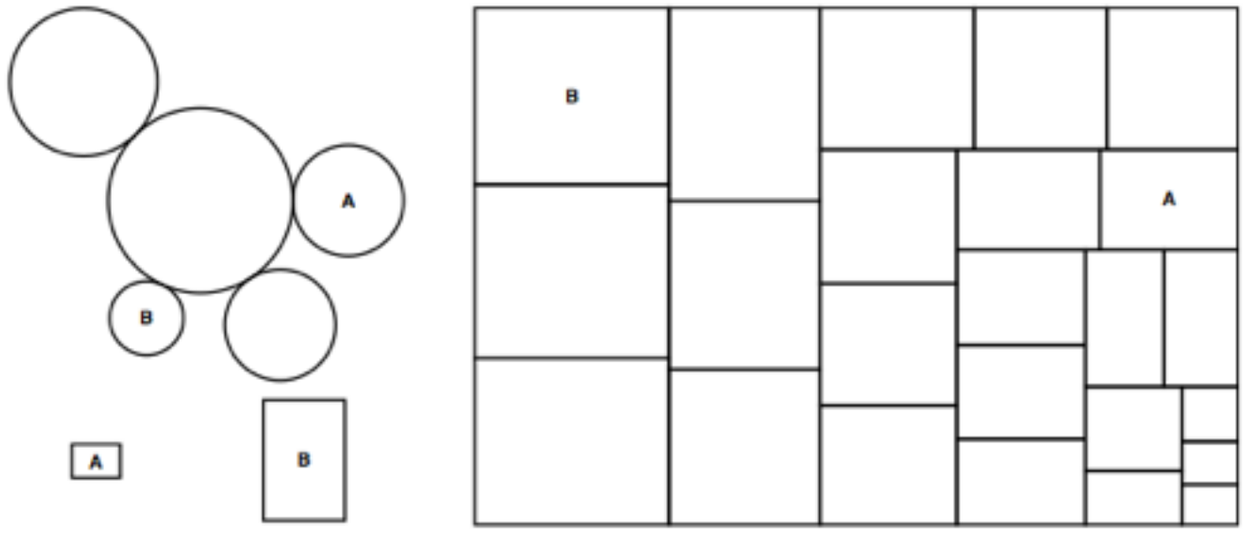
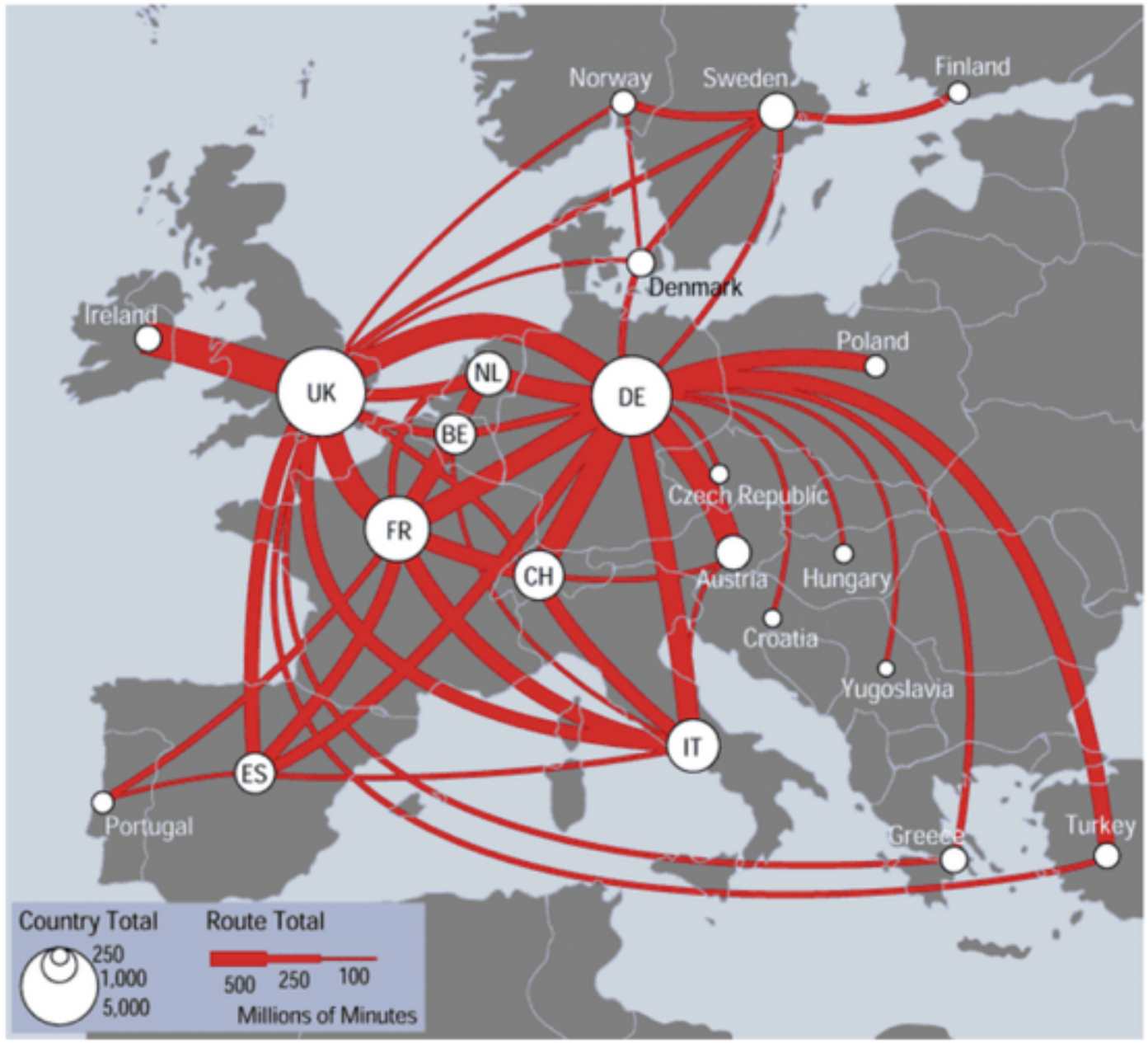


Figure 2: Area judgment stimuli. Top left: Bubble chart (T7), Bottom left: Center-aligned rectangles (T8), Right: Treemap (T9).

DISCRIMINABILITY

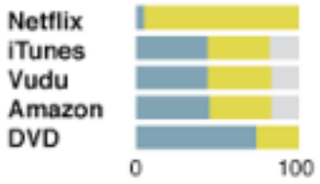
can channel differences be discerned?



Streaming the Box Office

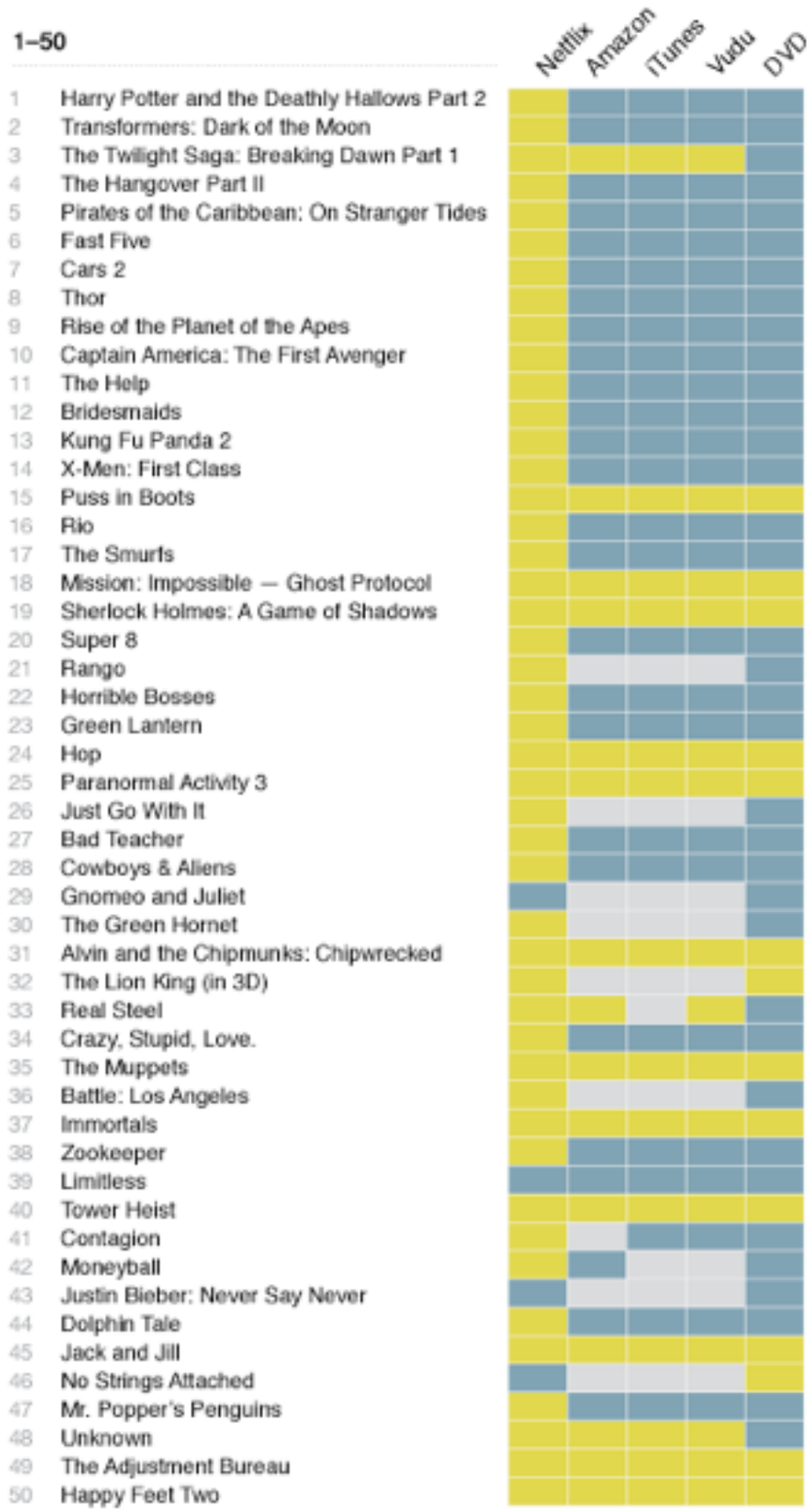
Top 100 in 2011

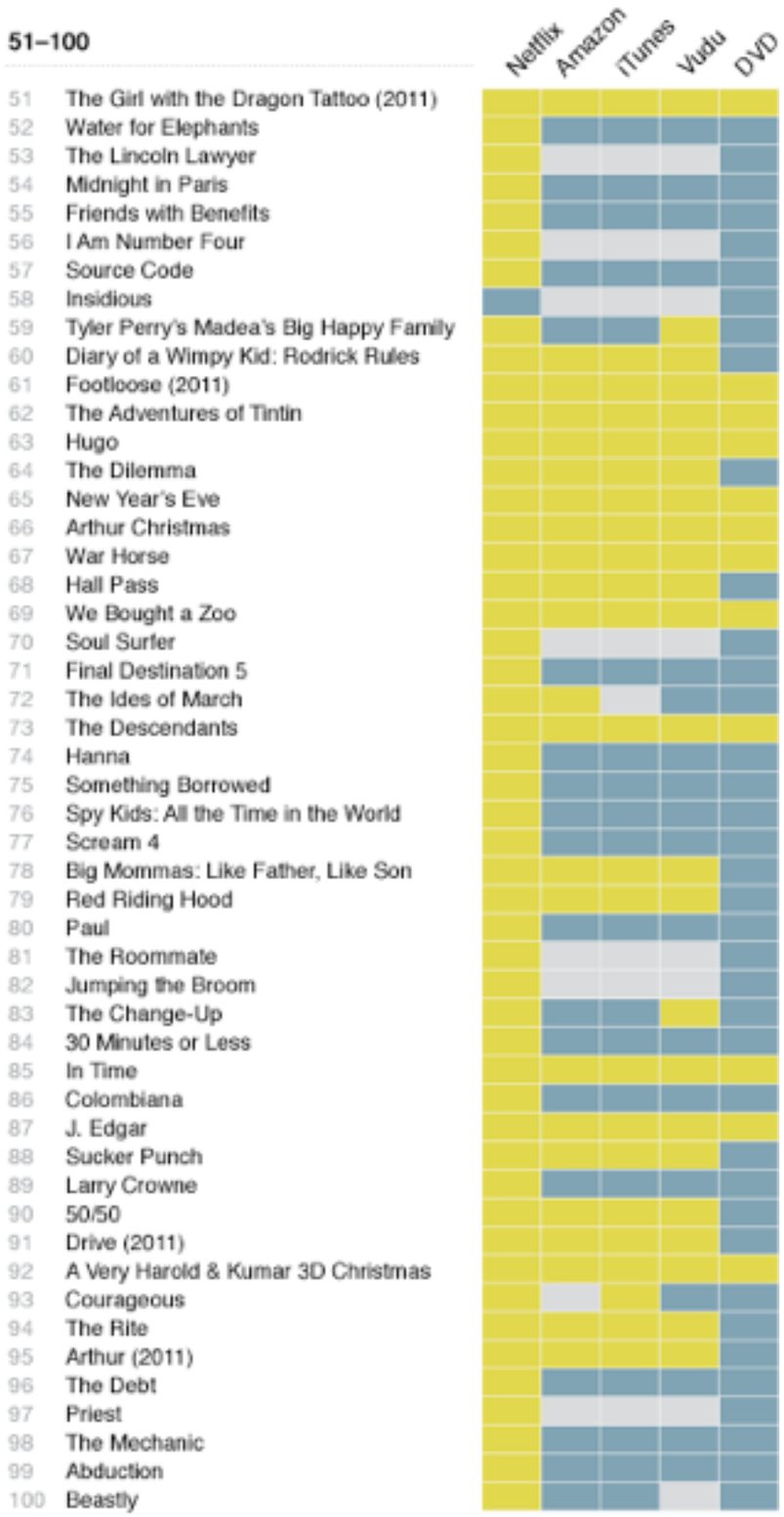
AVAILABLE
NOT AVAILABLE
PURCHASE ONLY



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



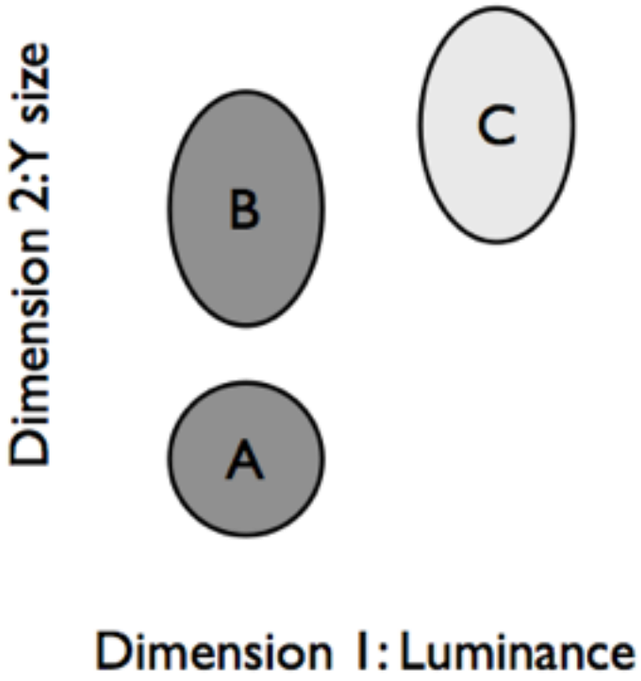


http://flowingdata.com/2012/01/20/where-are-the-biggest-box-office-movies-streaming/

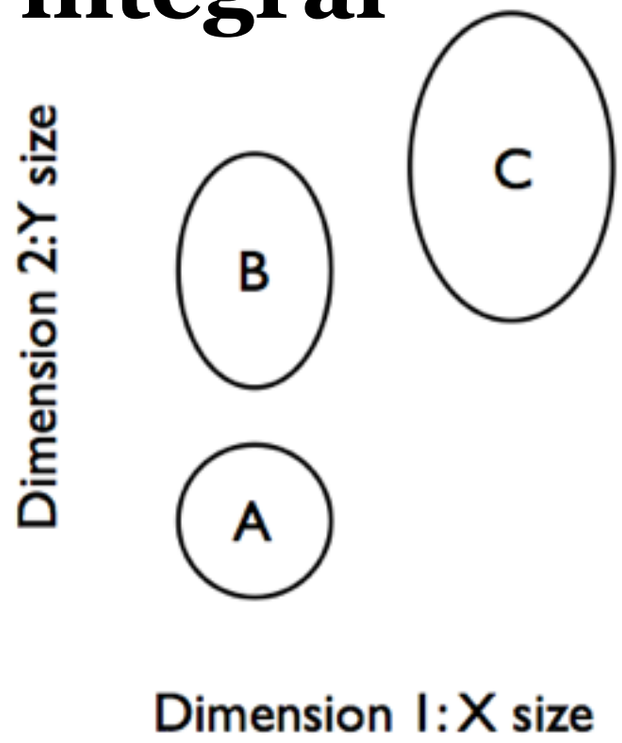
SEPARABLE vs INTEGRAL

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

separable



integral



Ware 2004

SEPARABLE vs INTEGRAL

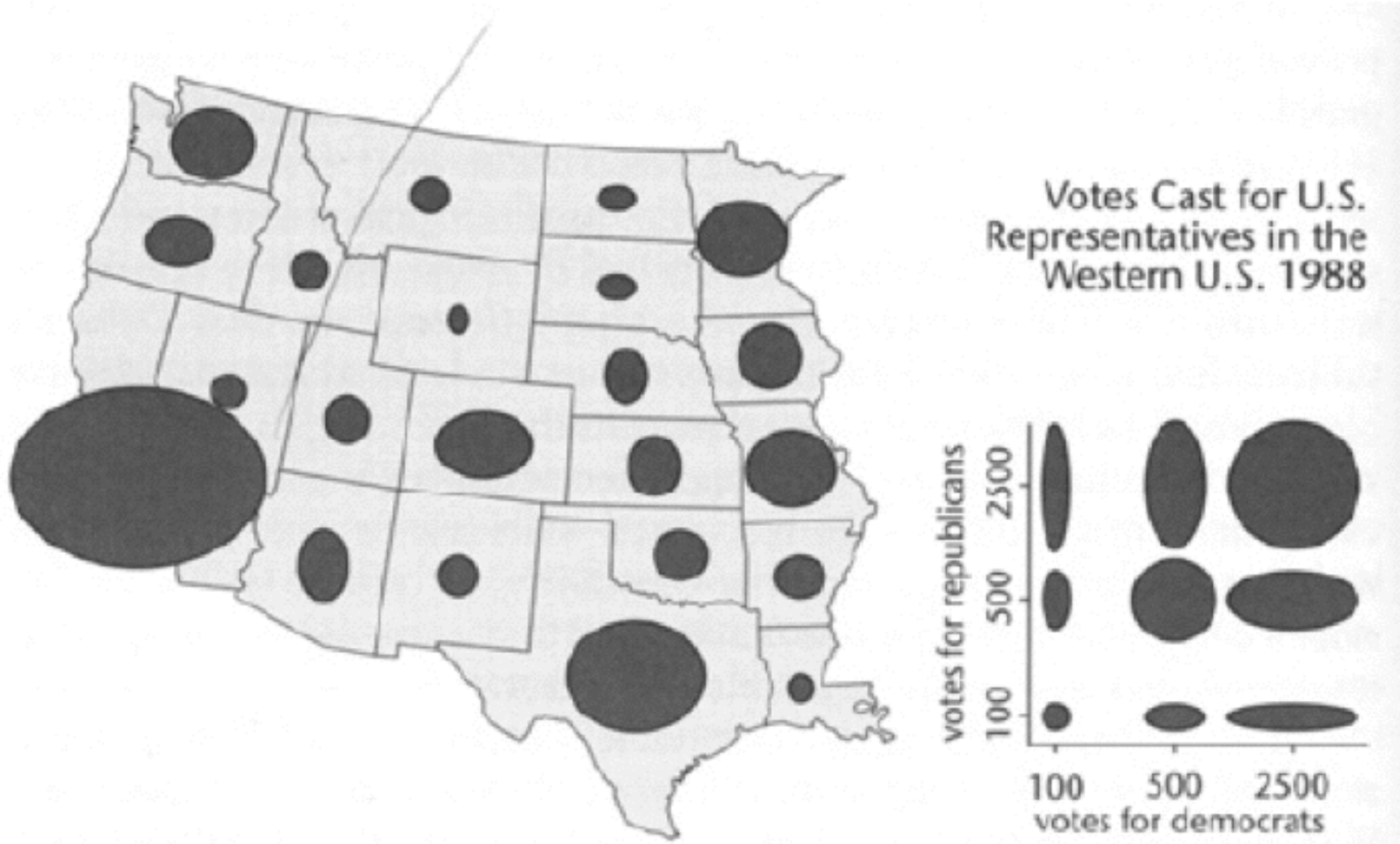


FIGURE 3.38. An example of the use of an ellipse as a map symbol in which the horizontal and vertical axes represent different (but presumably related) variables.

MacEachren 1995

SEPARABLE vs INTEGRAL

separable ⟷ integral

color | location

color | shape

x-size | y-size

color | motion

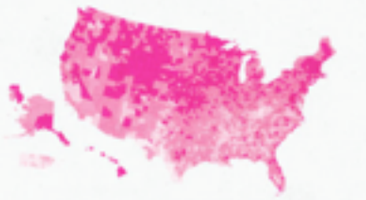
size | orientation

red-green | yellow-blue

Ware 2004

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.



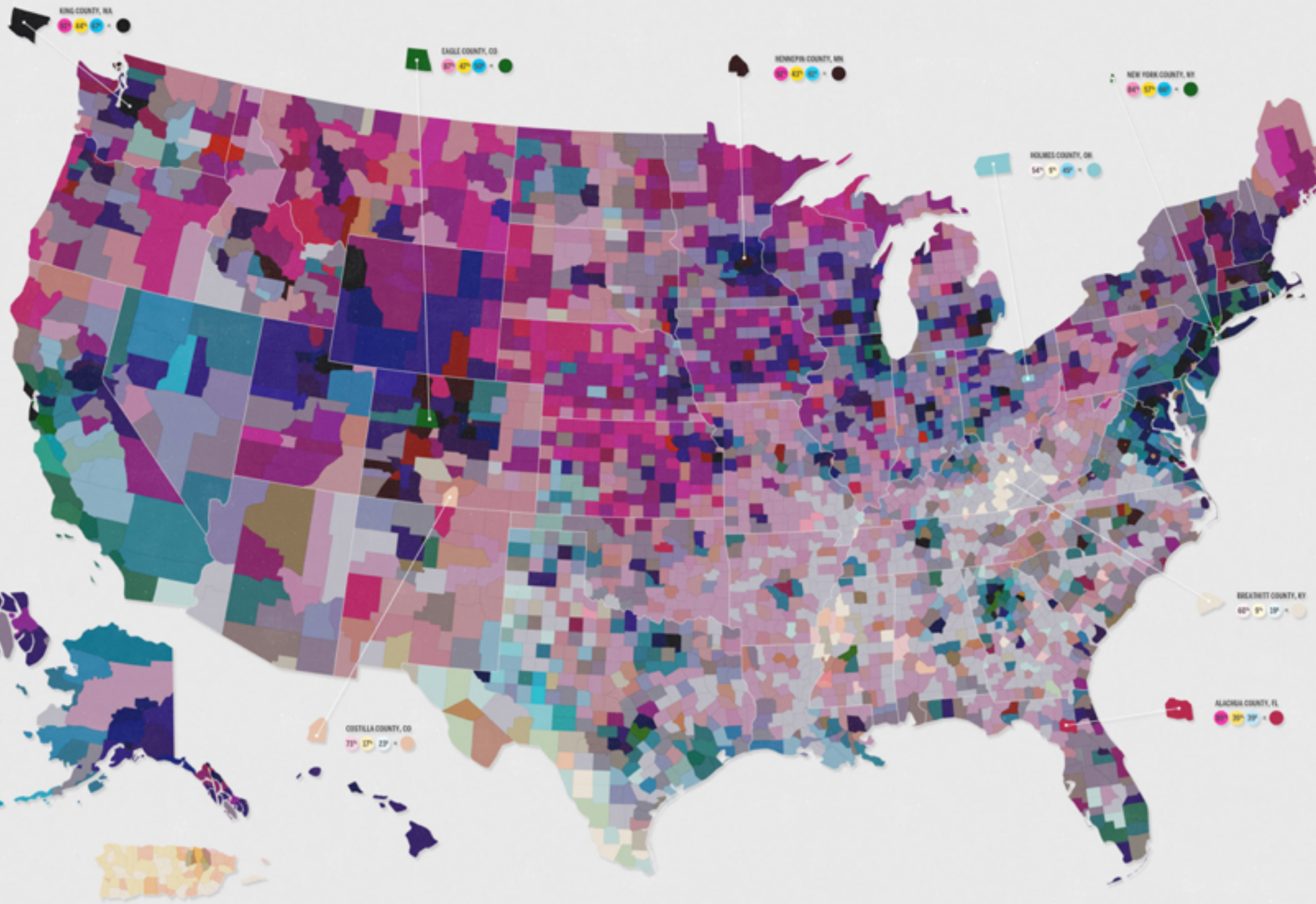
① HIGH SCHOOL GRADUATES 65% 75% 82% 93%

② COLLEGE GRADUATES 15% 22% 30% 40%

③ 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 Rubacek
SOURCE: US Census



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

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.

Ware 2010

+ *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

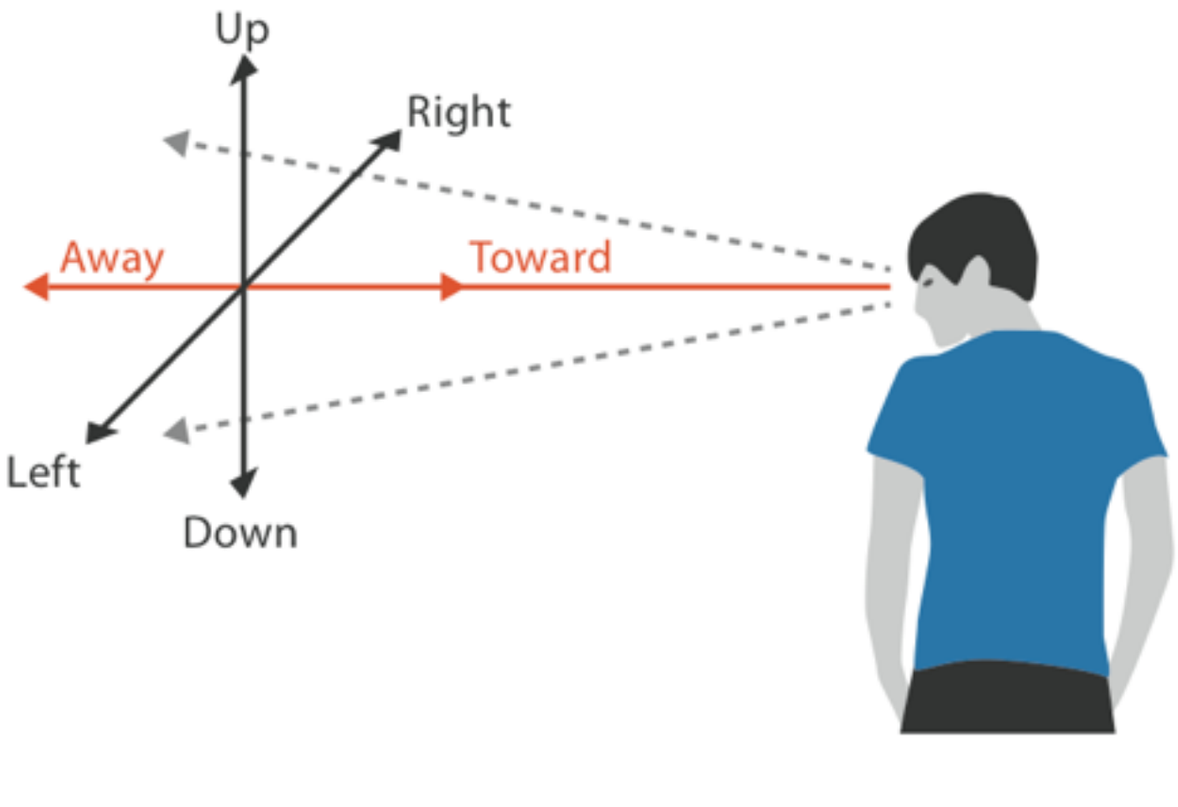
Motion

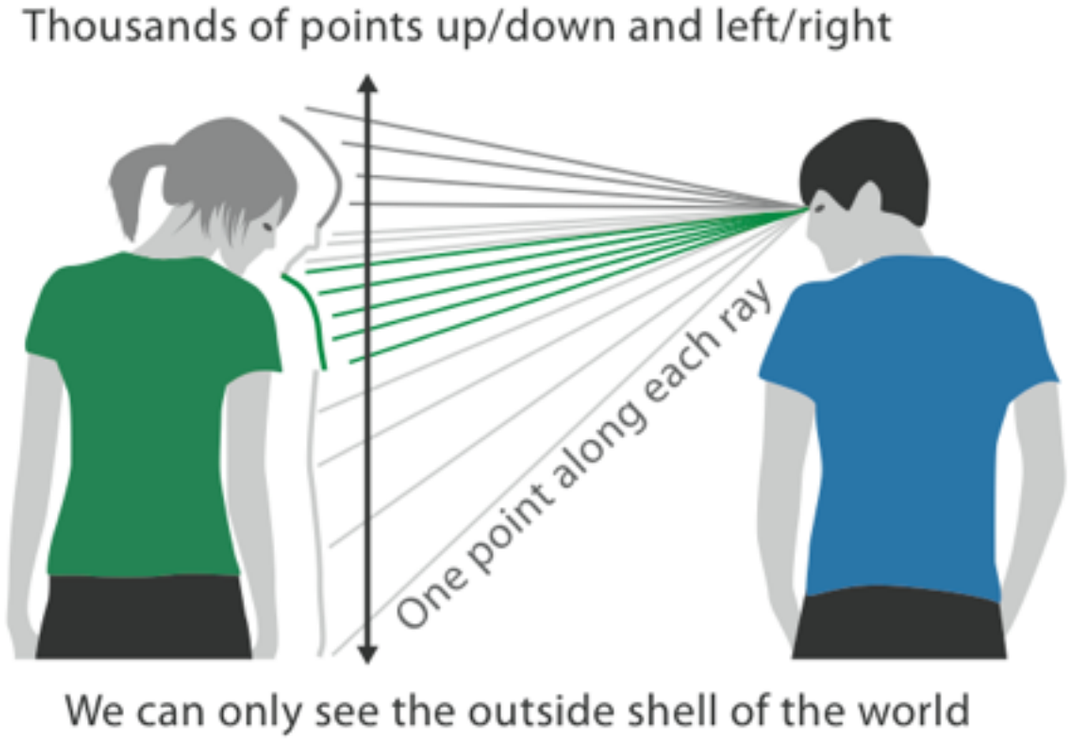
Shape

we see the world as a 2.5D space

we see the world as a ~~2.5D~~ 2.05D space

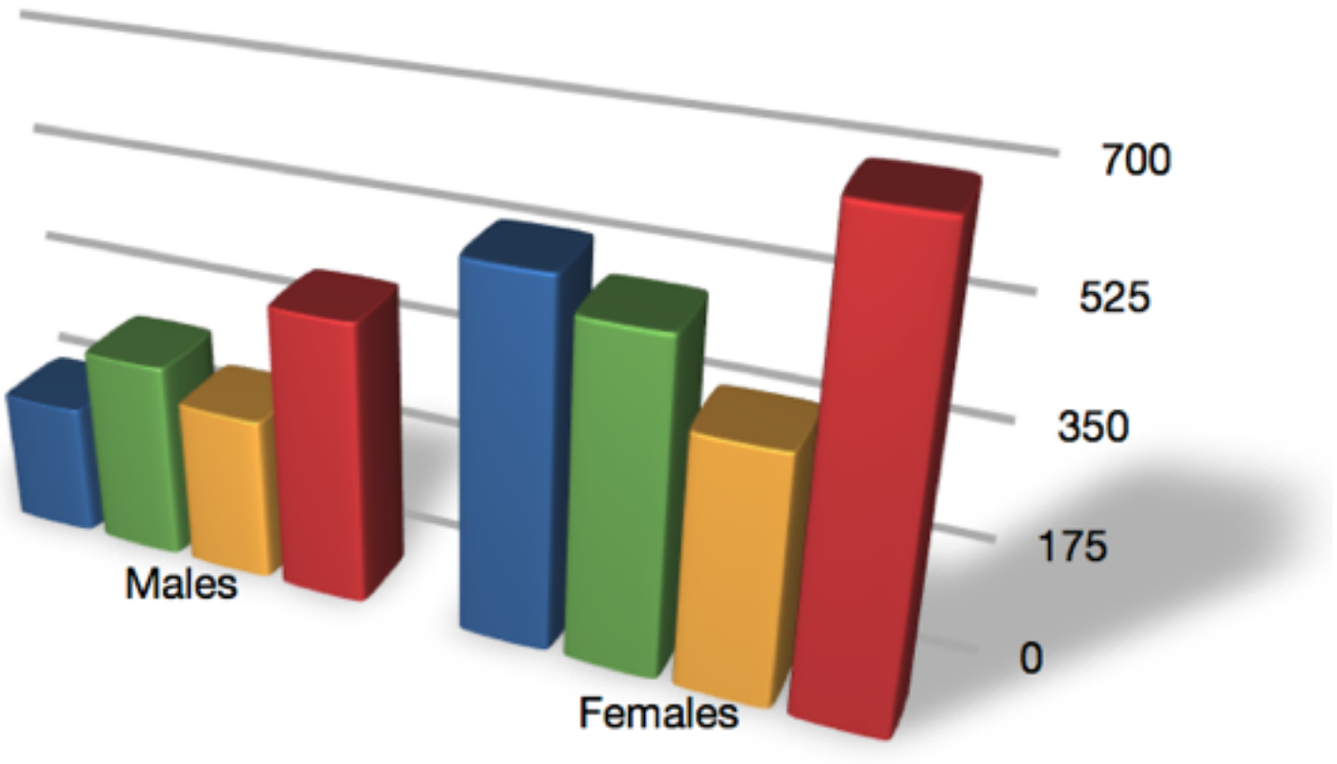
we see the world as a ~~2.5D~~ 2.05D space

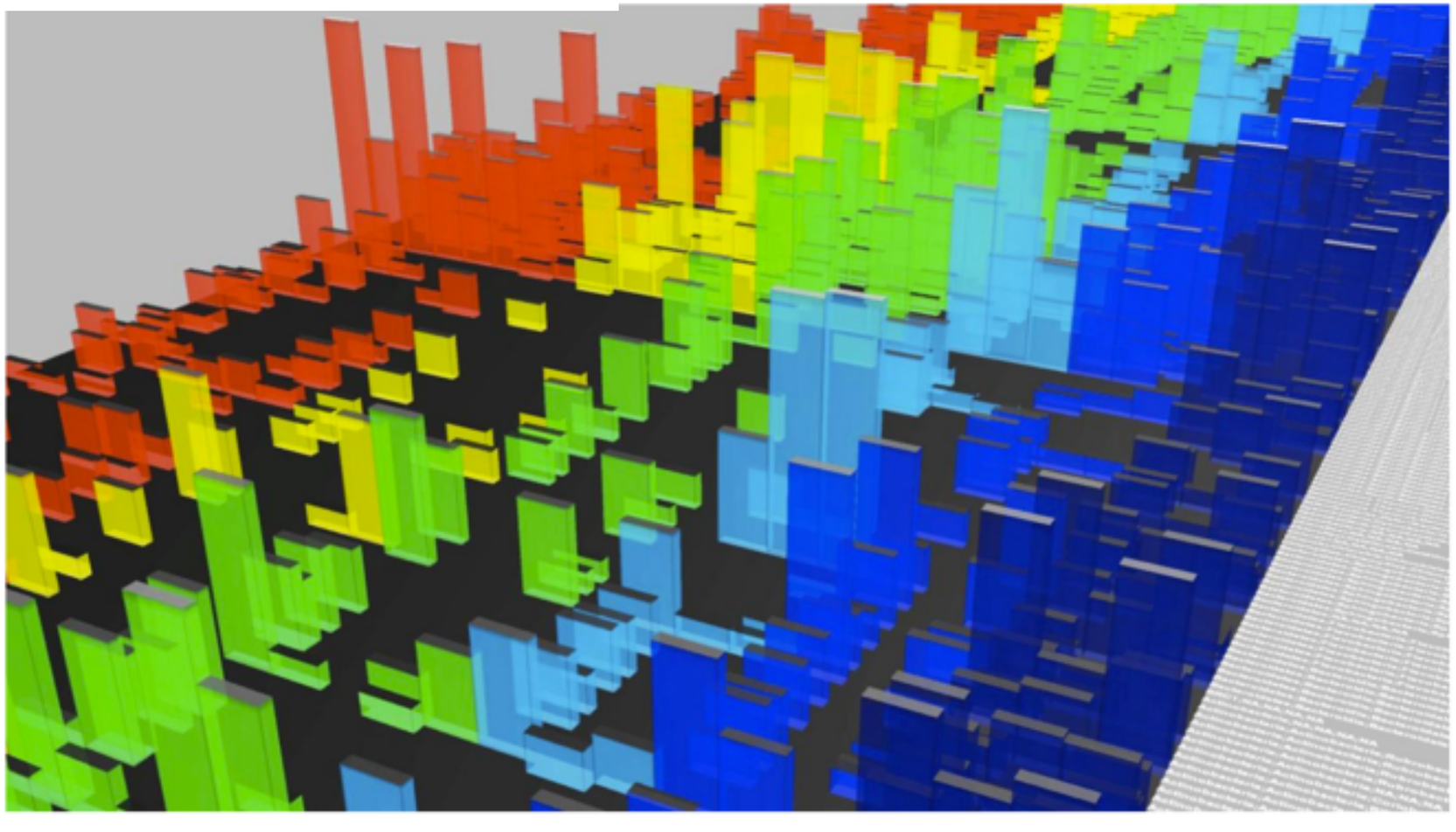




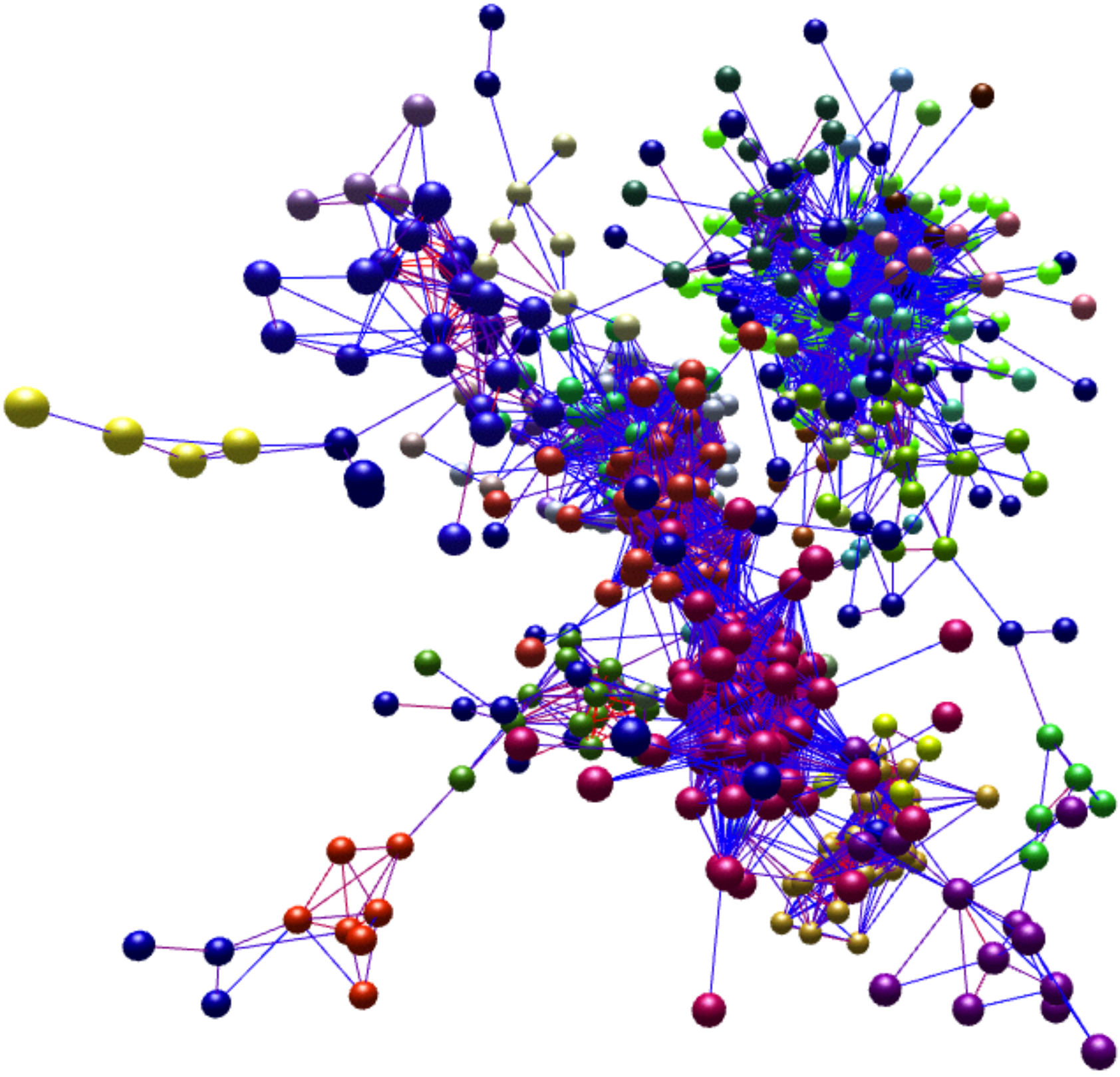
We can only see the outside shell of the world

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



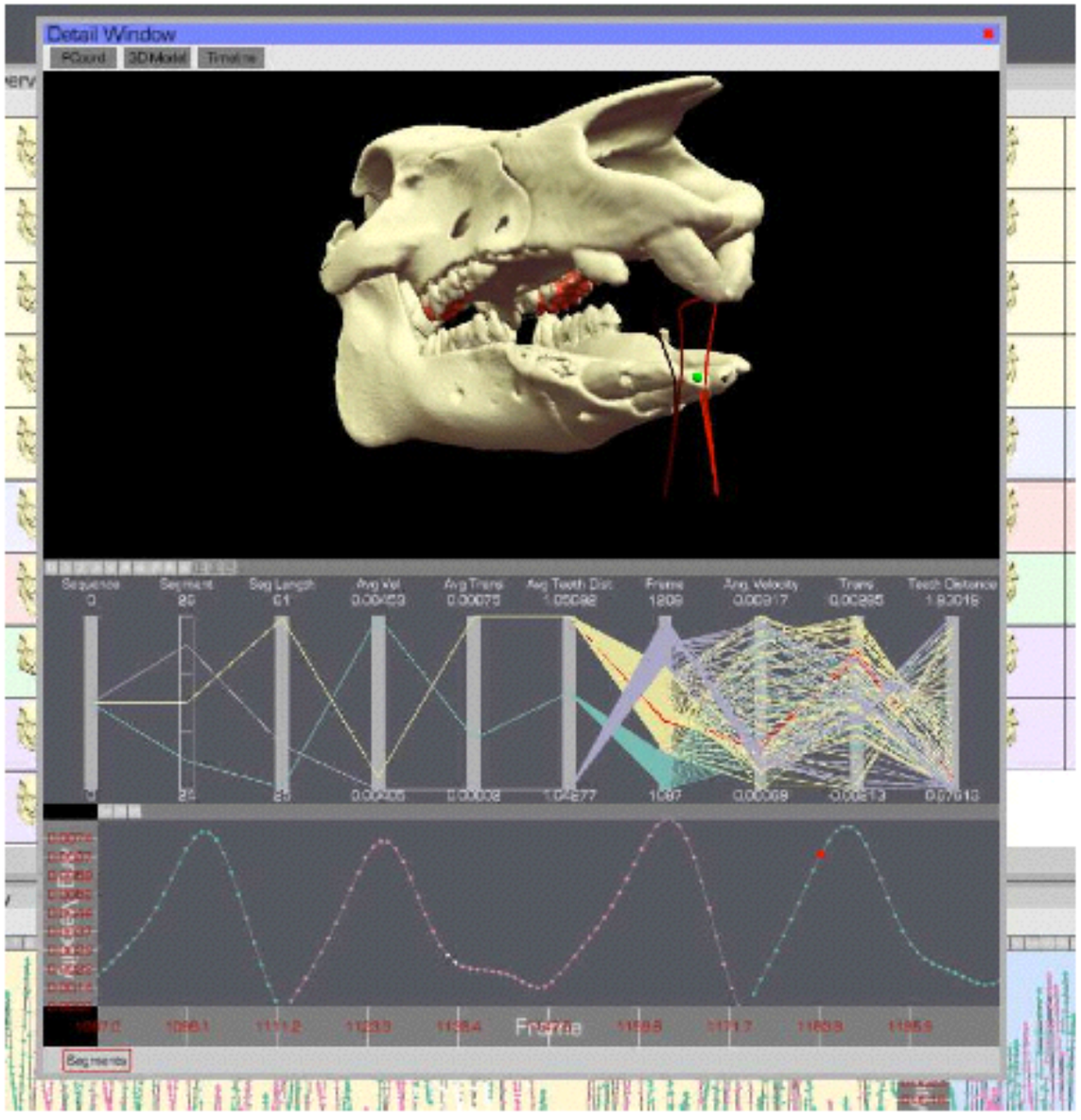


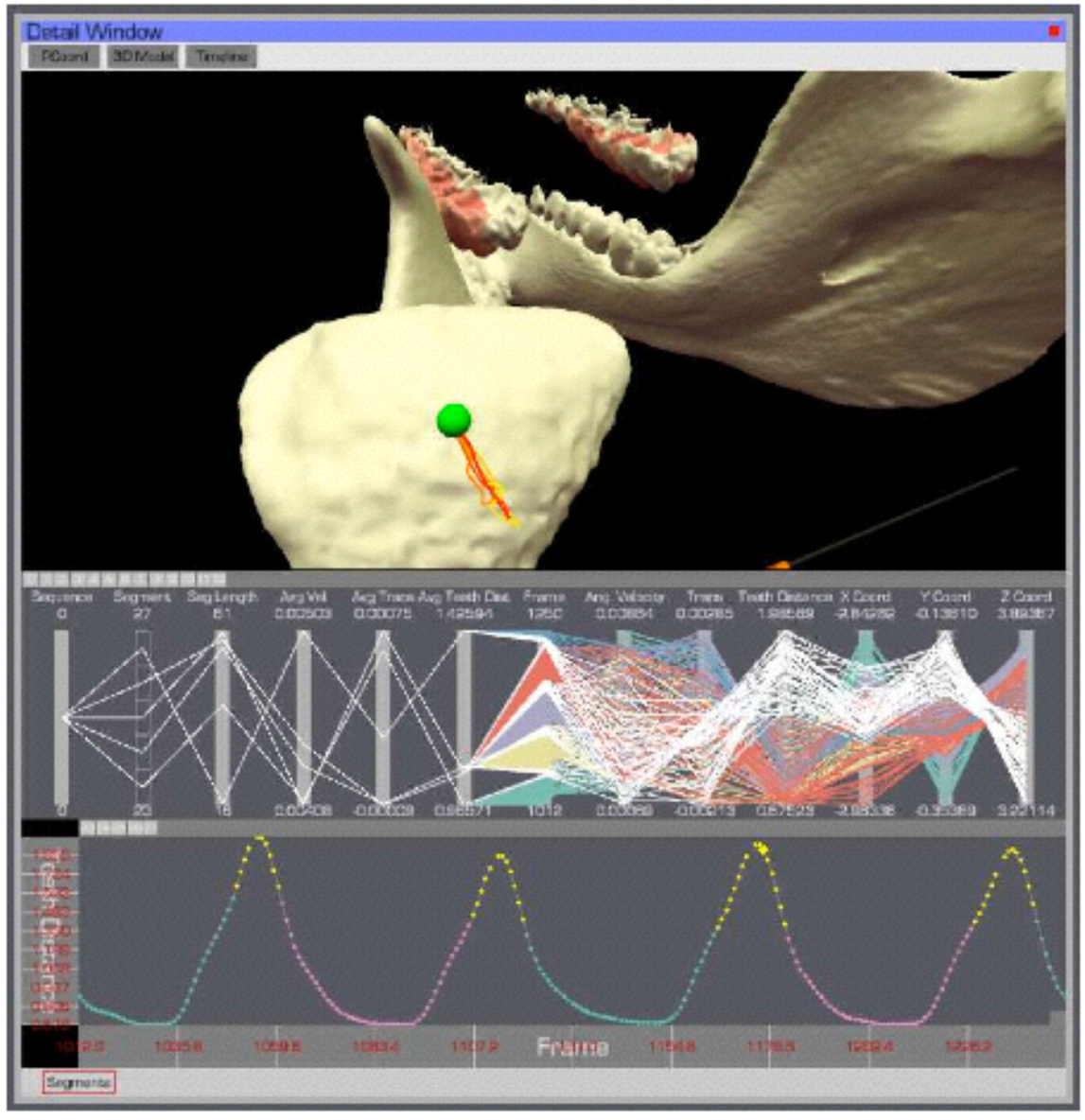
Moore 2011



http://www.biolayout.org/

2D and 3D?





Keefe 2008

- 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*

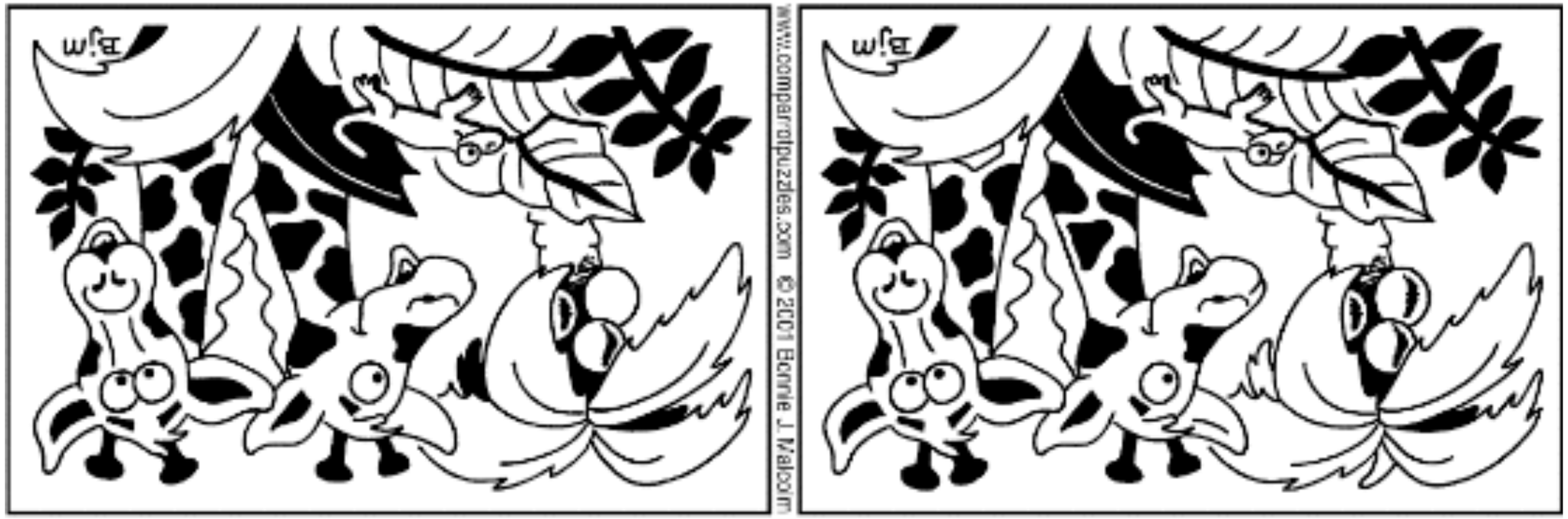
ComParrot
by Bonnie J. Malcolm

Can you spot 12 differences between these pictures?

ComParrot
by Bonnie J. Malcolm

Can you spot 12 differences between these pictures?

Solution: 1. Top tree leaf removed. 2. Nose line on left giraffe removed. 3. Shadow on lower left coconut removed. 4. Leaf vein below gecko removed. 5. Ear line on left giraffe removed. 6. Bottom spot on right giraffe colored in. 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 side shorter. 11. Gecko tail longer. 12. Gecko eye missing.



ComParrot Can you spot 12 differences between these pictures?

by Bonnie J. Malcolm

Int. J. Human-Computer Studies (2002) **57,** 247–262
doi:10.1006/ijhc.1017
Available online at http://www.idealibrary.com.on IDEAL®

Animation: can it facilitate?

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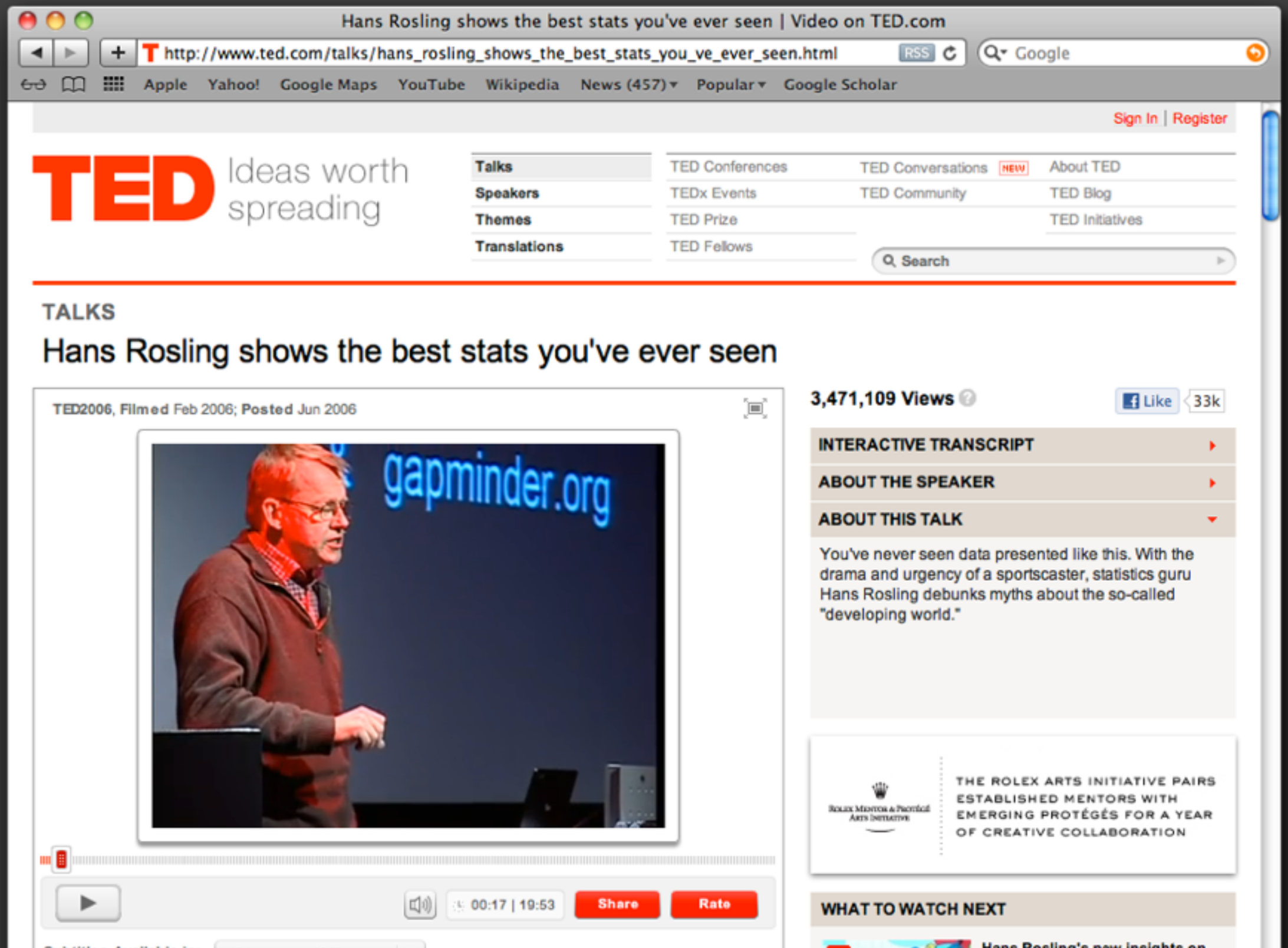
(Received 1 March 2001 and accepted in revised form 4 April 2002)

RECOMMENDED READING

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

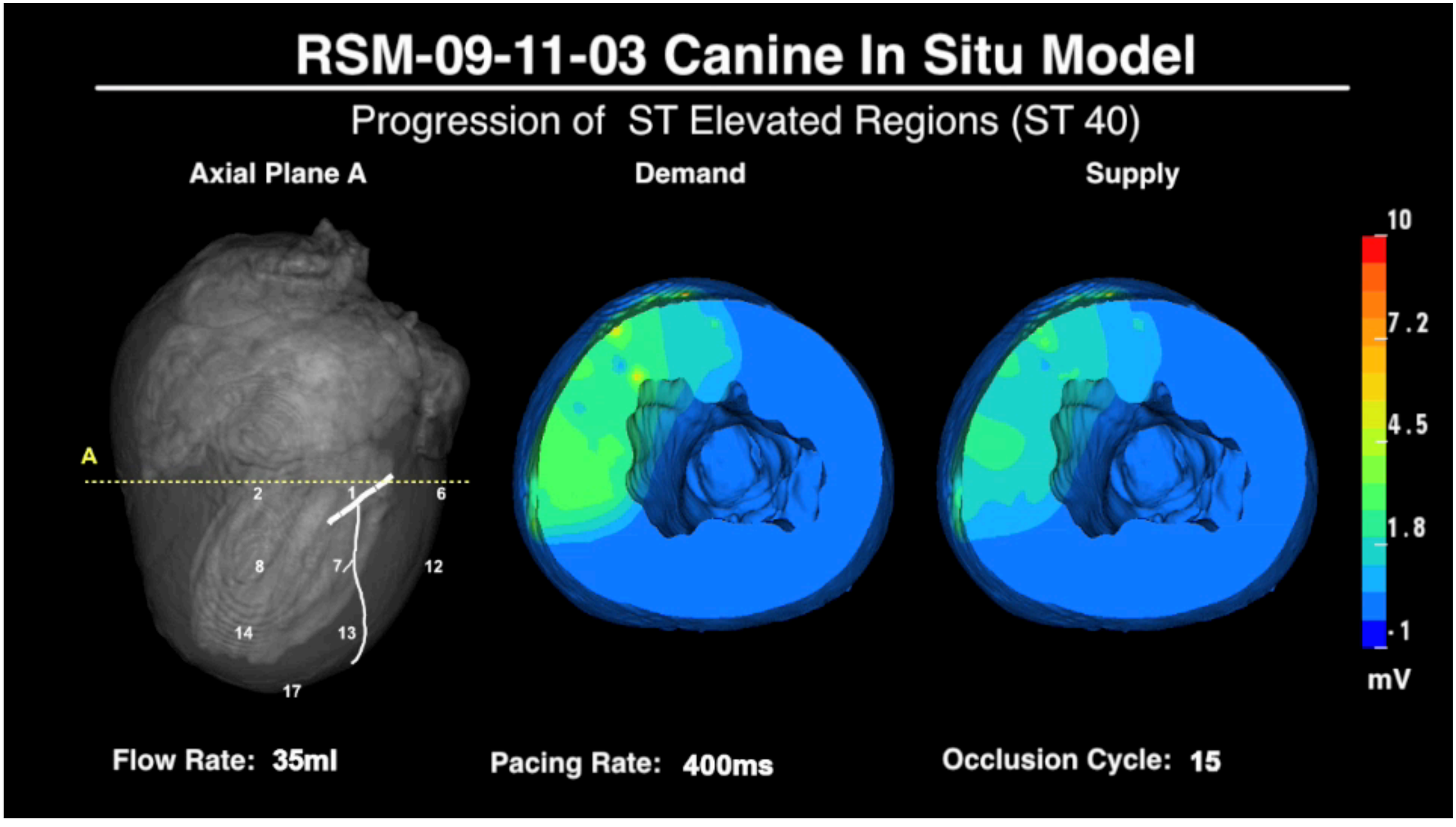
GOOD: STORYTELLING



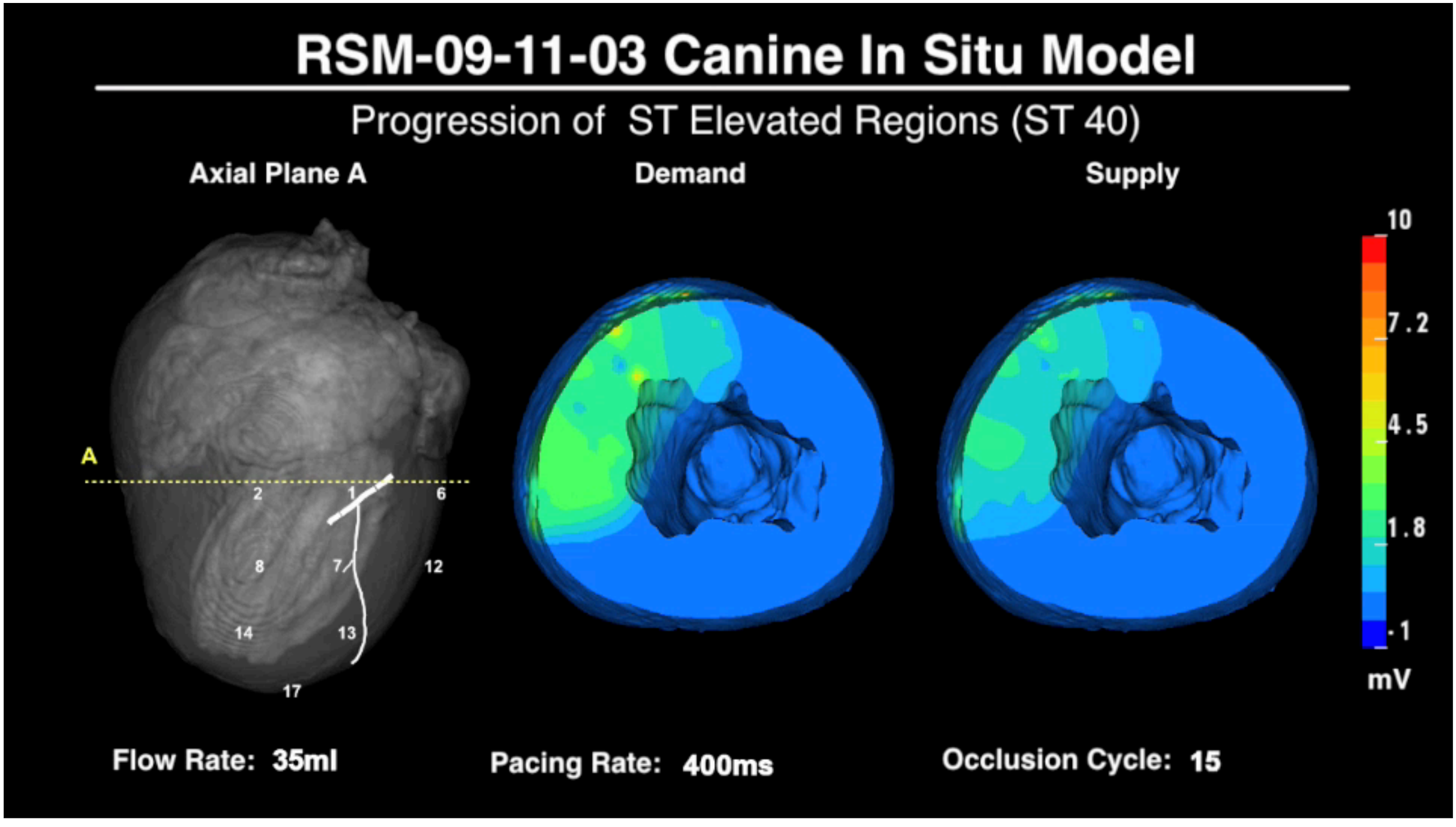
GOOD: TRANSITIONS

GOOD: TRANSITIONS

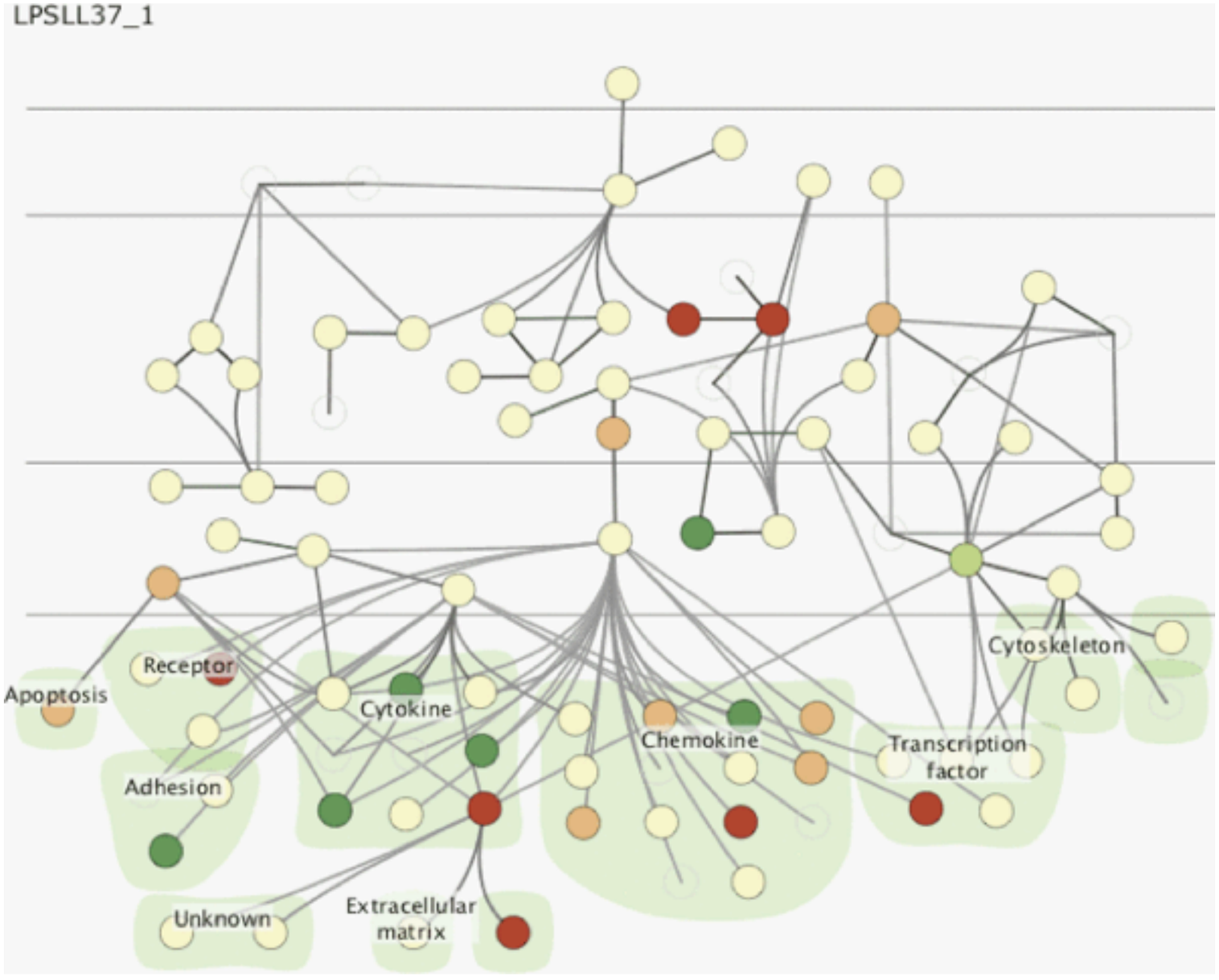
BAD: COMPARING COMPLEX STATE CHANGES OVER TIME



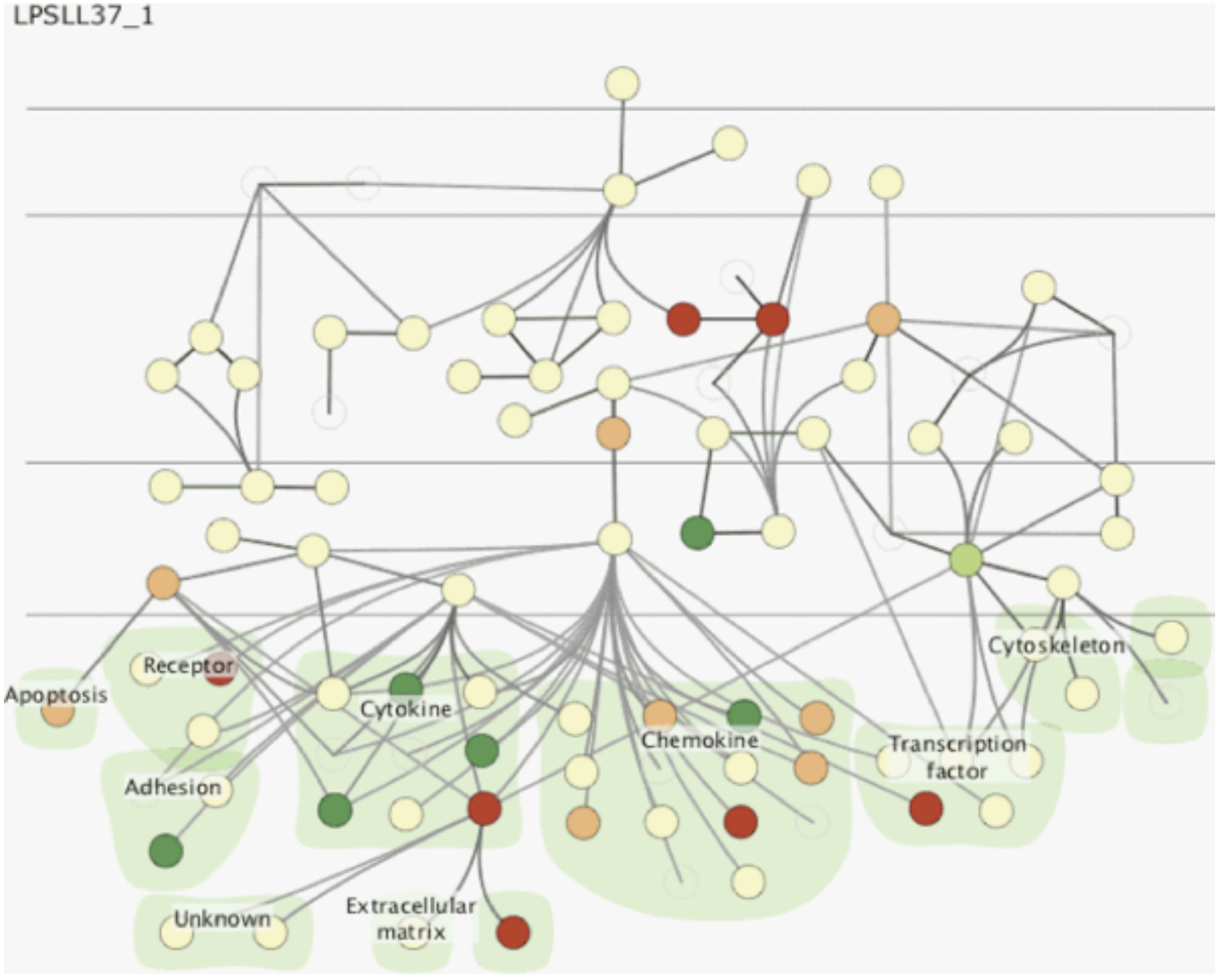
BAD: COMPARING COMPLEX STATE CHANGES OVER TIME



BAD: MULTIPLE STATES WITH MULTIPLE CHANGES

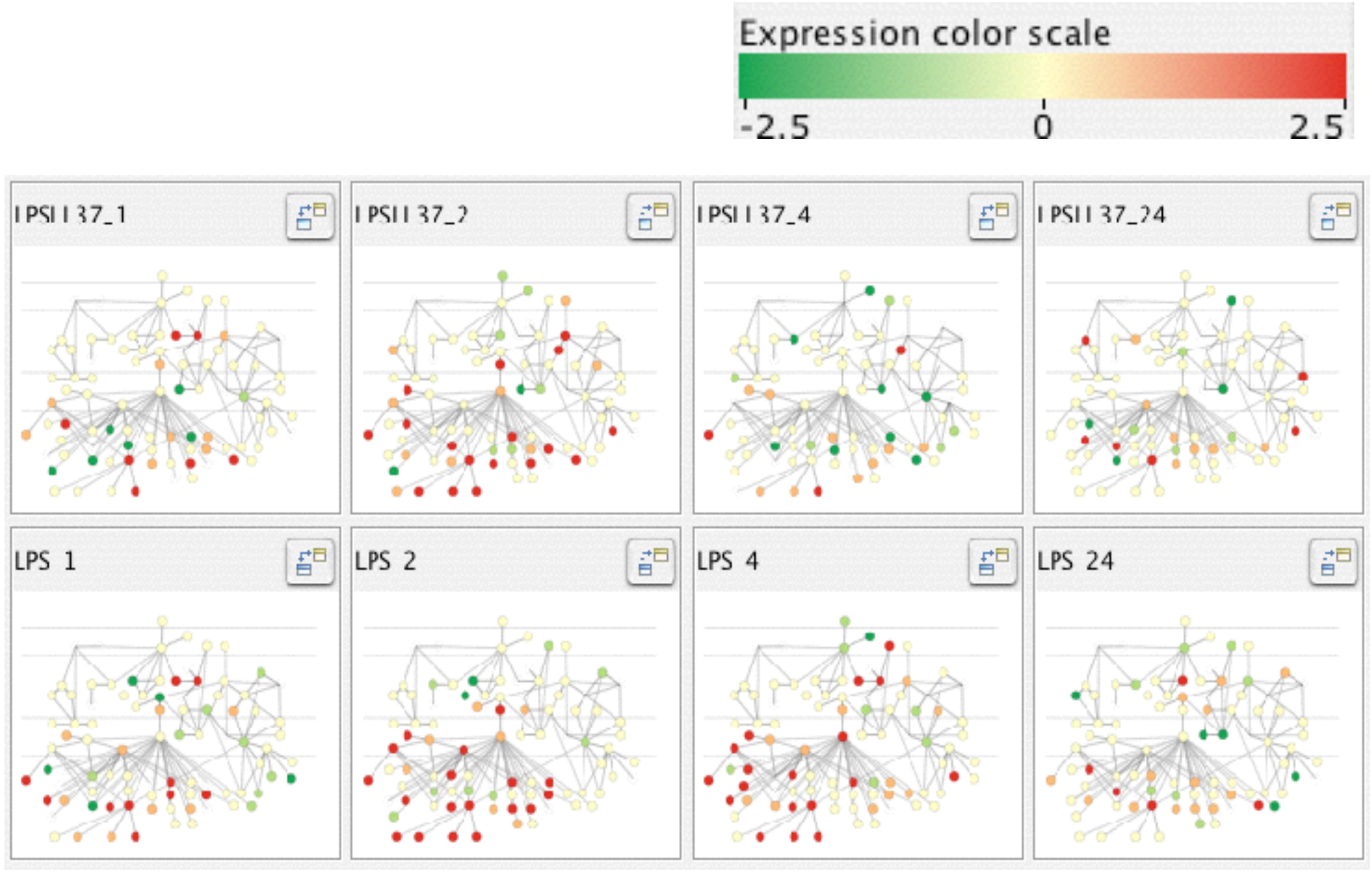


BAD: MULTIPLE STATES WITH MULTIPLE CHANGES



BAD: MULTIPLE STATES WITH MULTIPLE CHANGES

alternative: small multiples



Barsky 2008

- 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.

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.