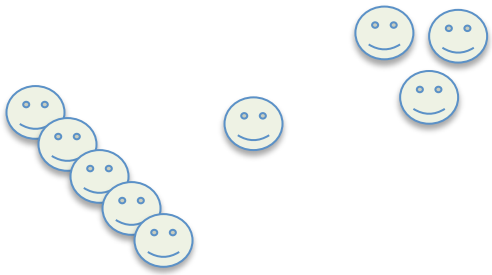
Visual Thinking

Structuring Two-Dimensional Space



June 2016
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Pattern processing*

Pattern perception –

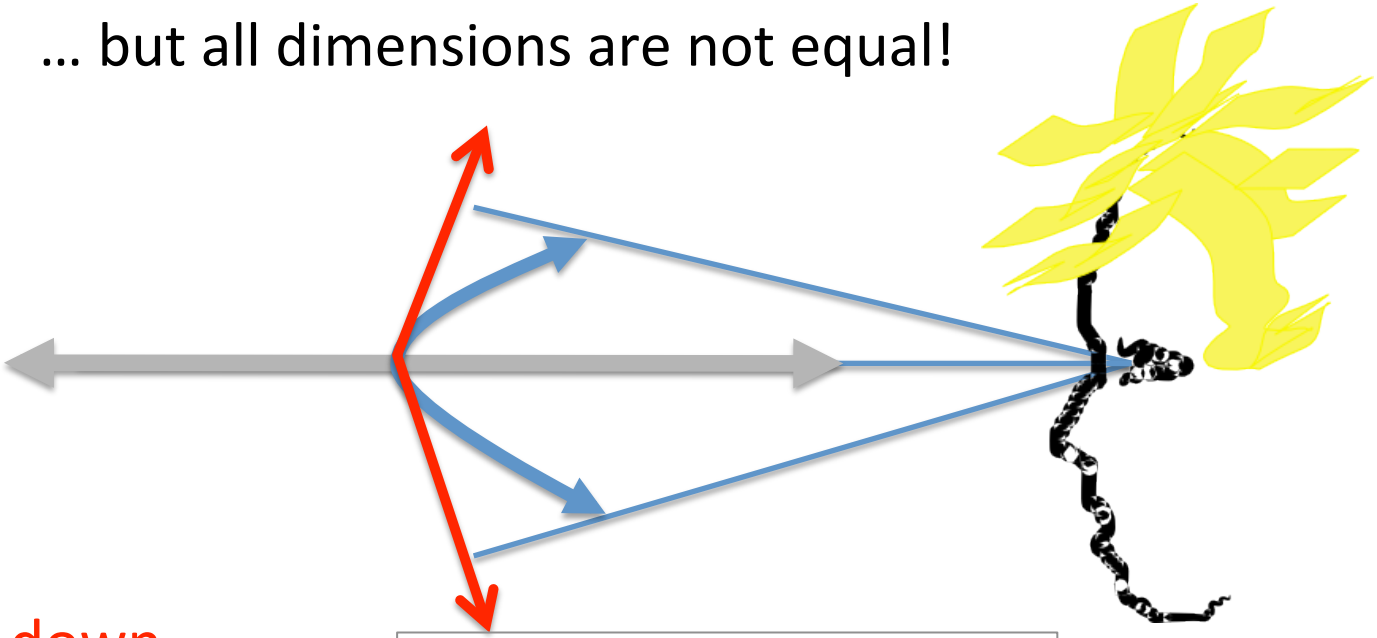
- where the **bottom-up** processes of **feature processing** meet the requirements of **active attention**
  - Objects are extracted from patterns of features
- Learning is important
  - "priming" ; once we recognize a pattern it is easier to spot later.
- Some patterns are easier to spot than others.
- Understanding pattern perception provides abstract design rules to tell us how we should organize data so that important structures will be perceived.
  - If we can map information structures to readily perceived patterns, then those structures will be more easily interpreted.

**Chapter 6, Information visualization: perception for design,* by Colin Ware

Space

- We live in a 3D world….

  … but all dimensions are not equal!



- up-down
- sideways
- towards-away

Actually more like 2.5 dimensions, where the 0.5 is the *away* dimension

or even 2.05 dimensions!

image plane + depth

Space again

To get information in up-down and sideways planes, we can rapidly sample with our eyes

- But to get information about depth, we need to **move**.

Image plane sampling is **10-100x more efficient** than depth sampling

- Pattern processing in the brain is mostly devoted to the image plane.
  - This section focuses on 2D pattern perception

Higher level order: Patterns

Human visual system is a powerful pattern seeker

- ideas+ physical evidence = pattern
  - We locate pattern with rapid visual searches

patterns are the essence of visual thinking

  - often to perceive a pattern is to gain an insight or solve a problem

'what' pathway – processes patterns to ultimately identify objects

  - Contours,texture, regions, motion
  - the building blocks of **objects**
  - or relationships between objects

- understanding how patterns are formed can inform the task of organising space:
  - unambiguous and clear

versus

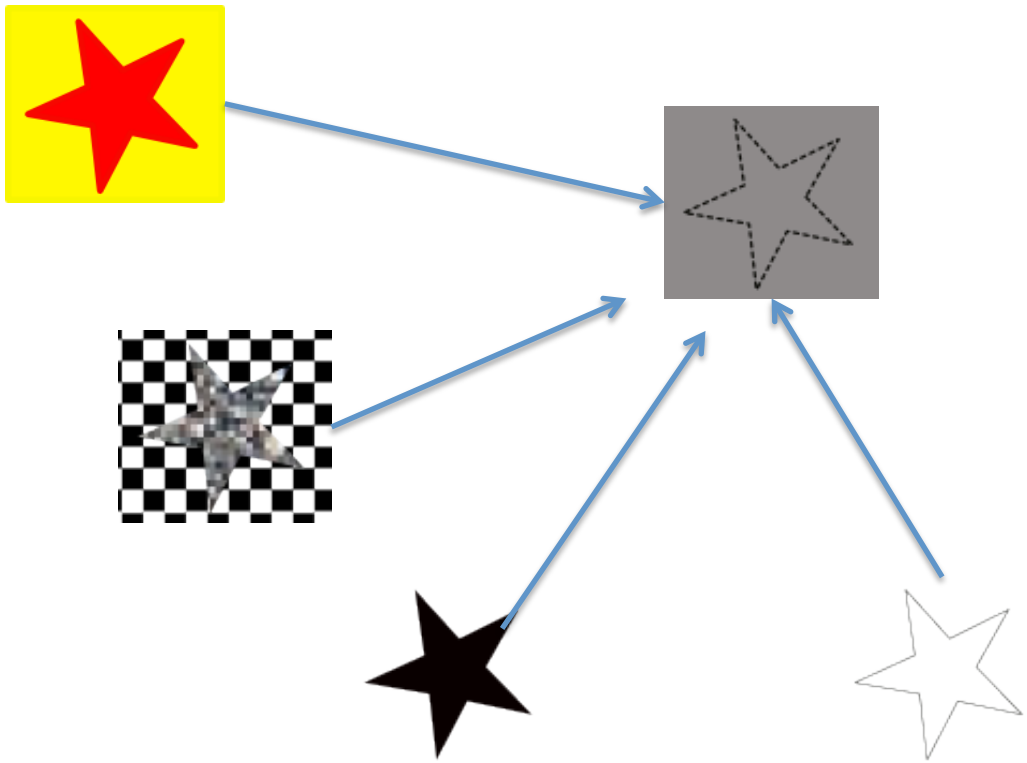
  - multiple interpretations

Pattern examples

- [shown on board]

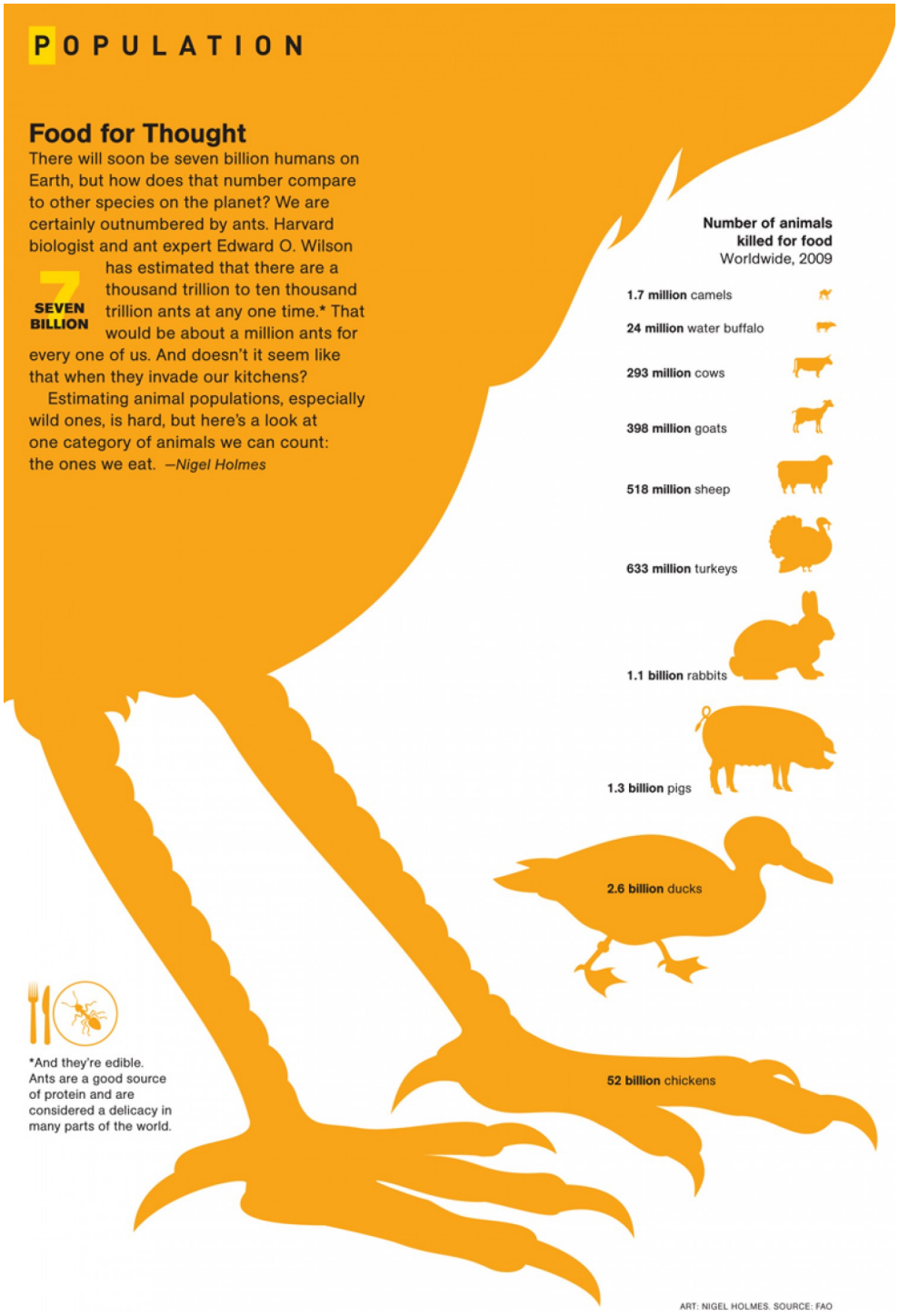
Generalized Contour

our brains have a *contour extraction mechanism*



Many different kinds of boundaries activate a generalized contour

This is why line drawings are so effective.

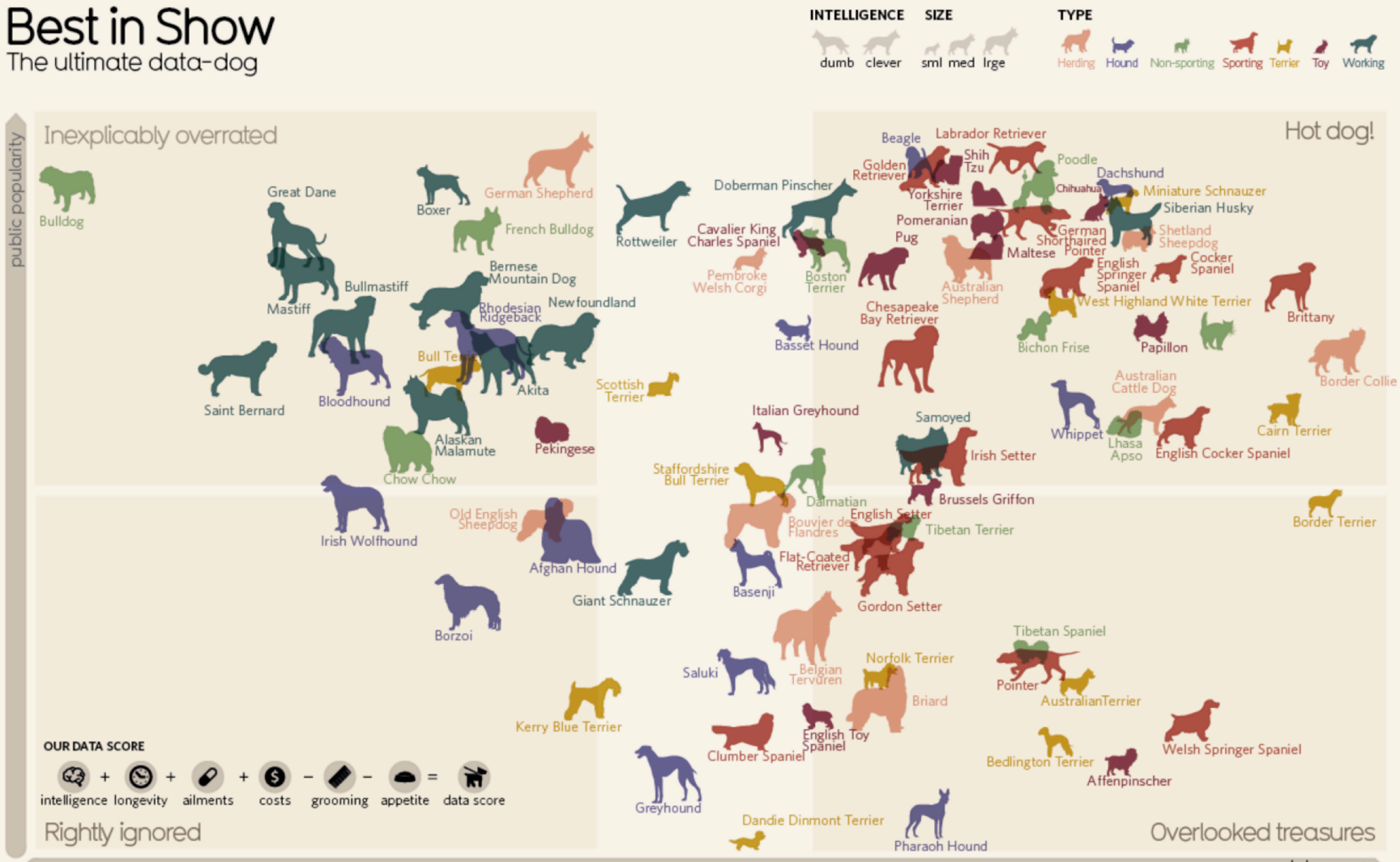


Contours

Source: National Geographic

Best in Show

The ultimate data-dog



by David McCandless

research: @MiriamQuick / dogs: Andrew Park @illustrationkid

informationisbeautiful.net

taken from the new, infographic mega-book

Knowledge is Beautiful

bit.ly/KIB_books

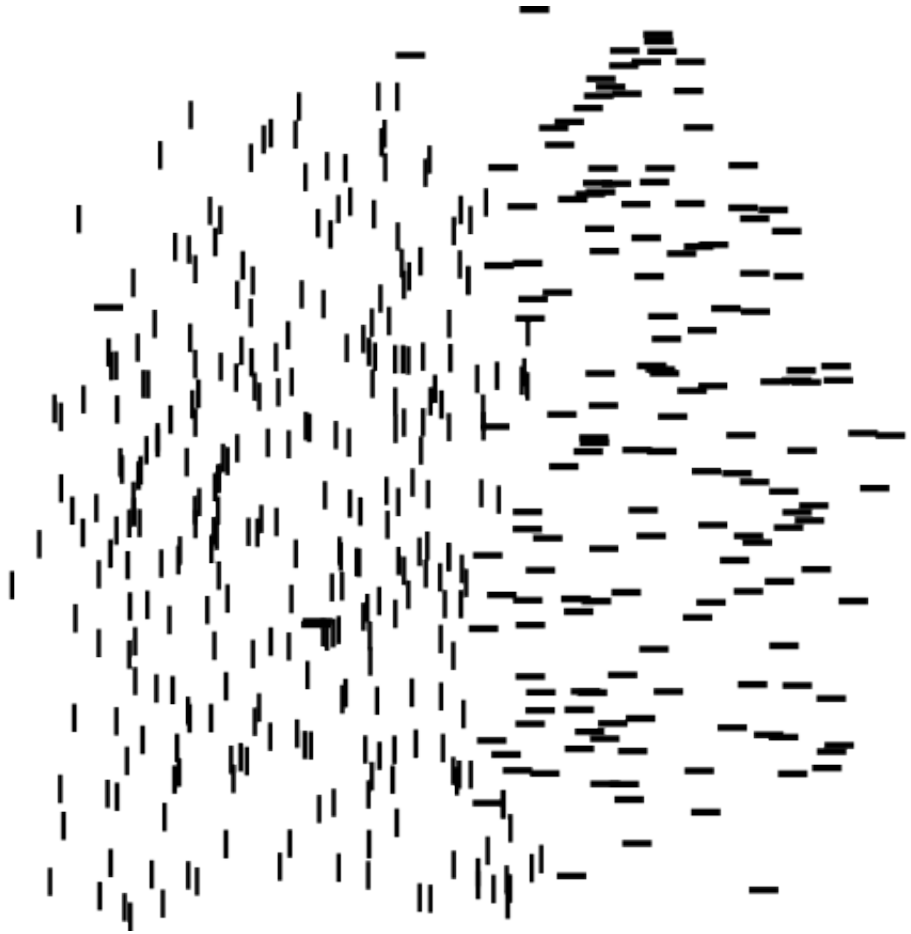
sources: American Kennel Club, Canine Inherited Disorders Database,

data: bit.ly/KIB_BestDogs

Texture regions

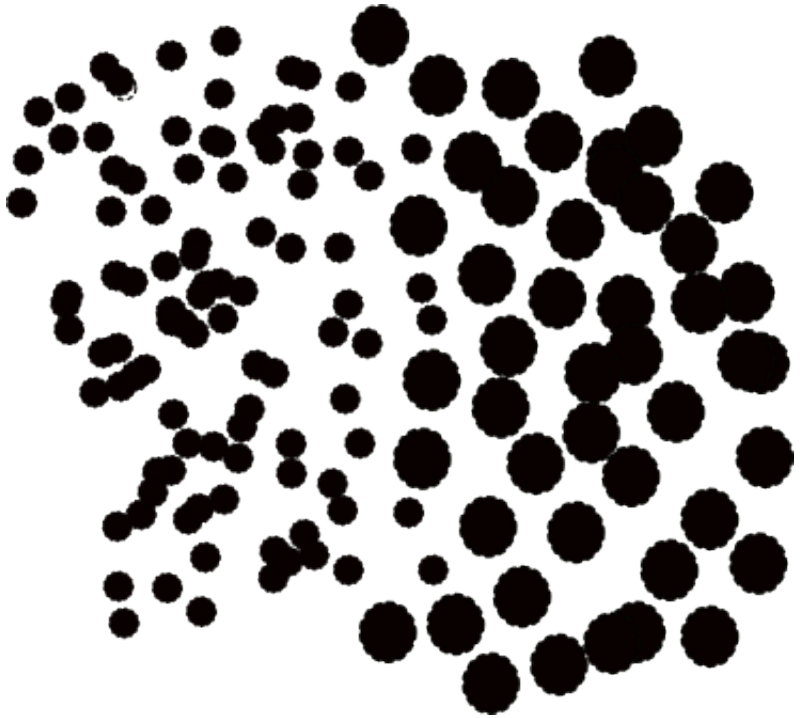
- Texture is distinguished in the same way as single objects – primary factors are grain size, orientation and contrast

Textures that are easy to distinguish



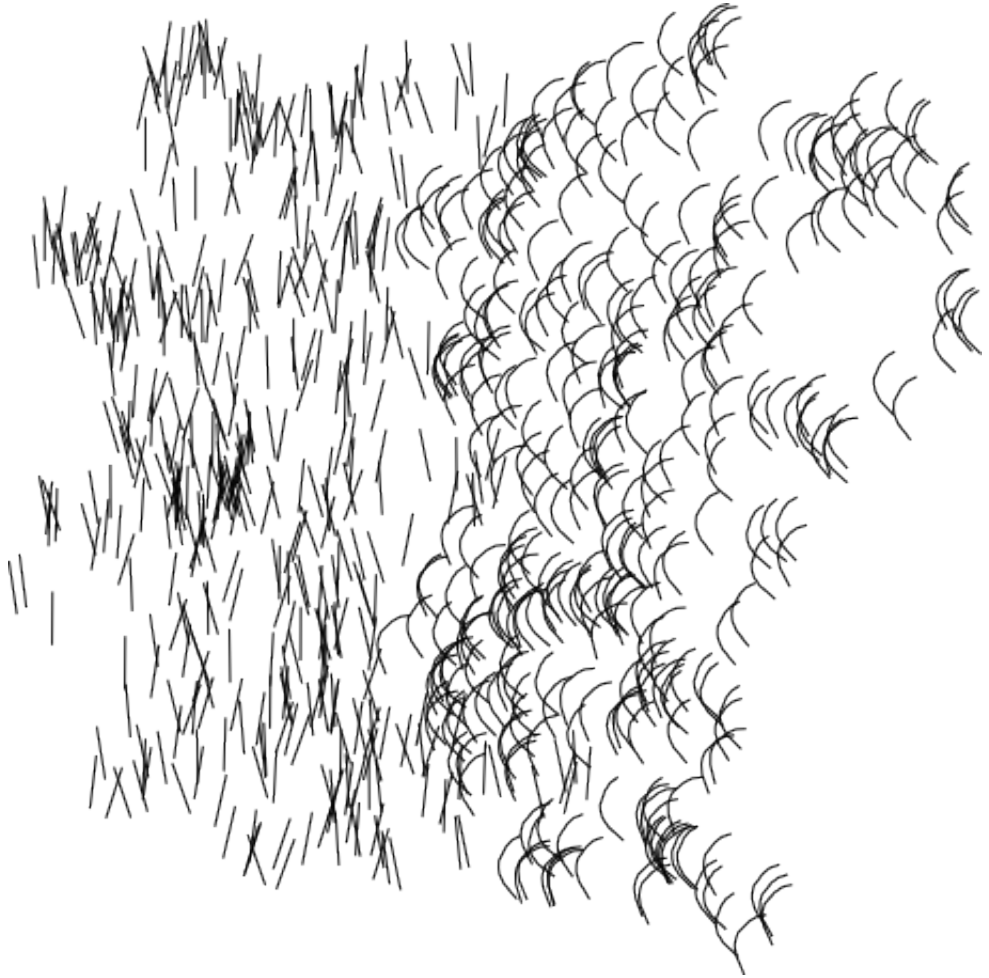
orientation

Textures that are easy to distinguish



grain size

Textures that are easy to distinguish

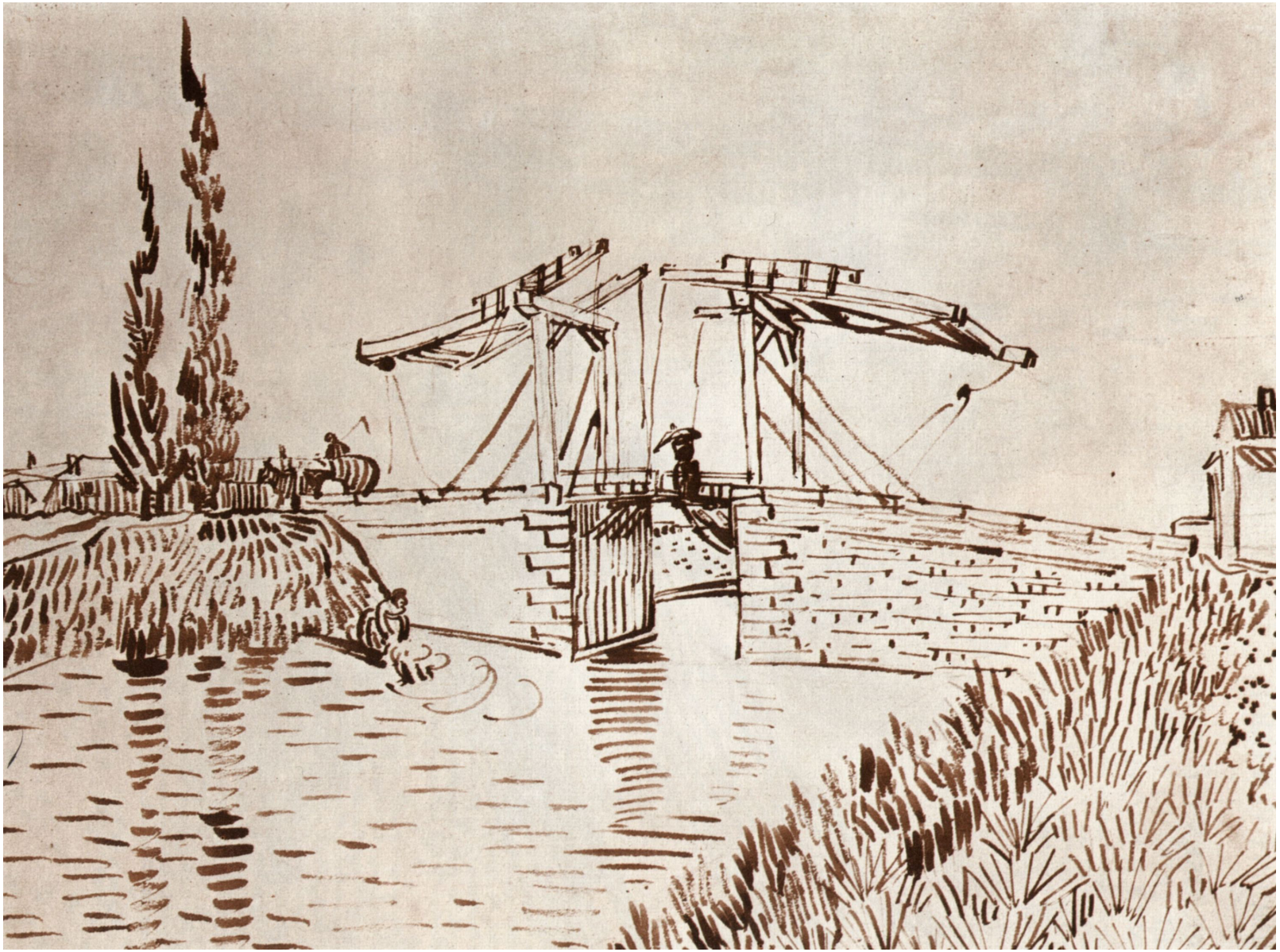


curved versus straight

Textures that are easy to distinguish

sharp versus blur

Landscape with the Wall of a Farm by Vincent Van Gogh - www.vangoghgallery.com 750 × 507



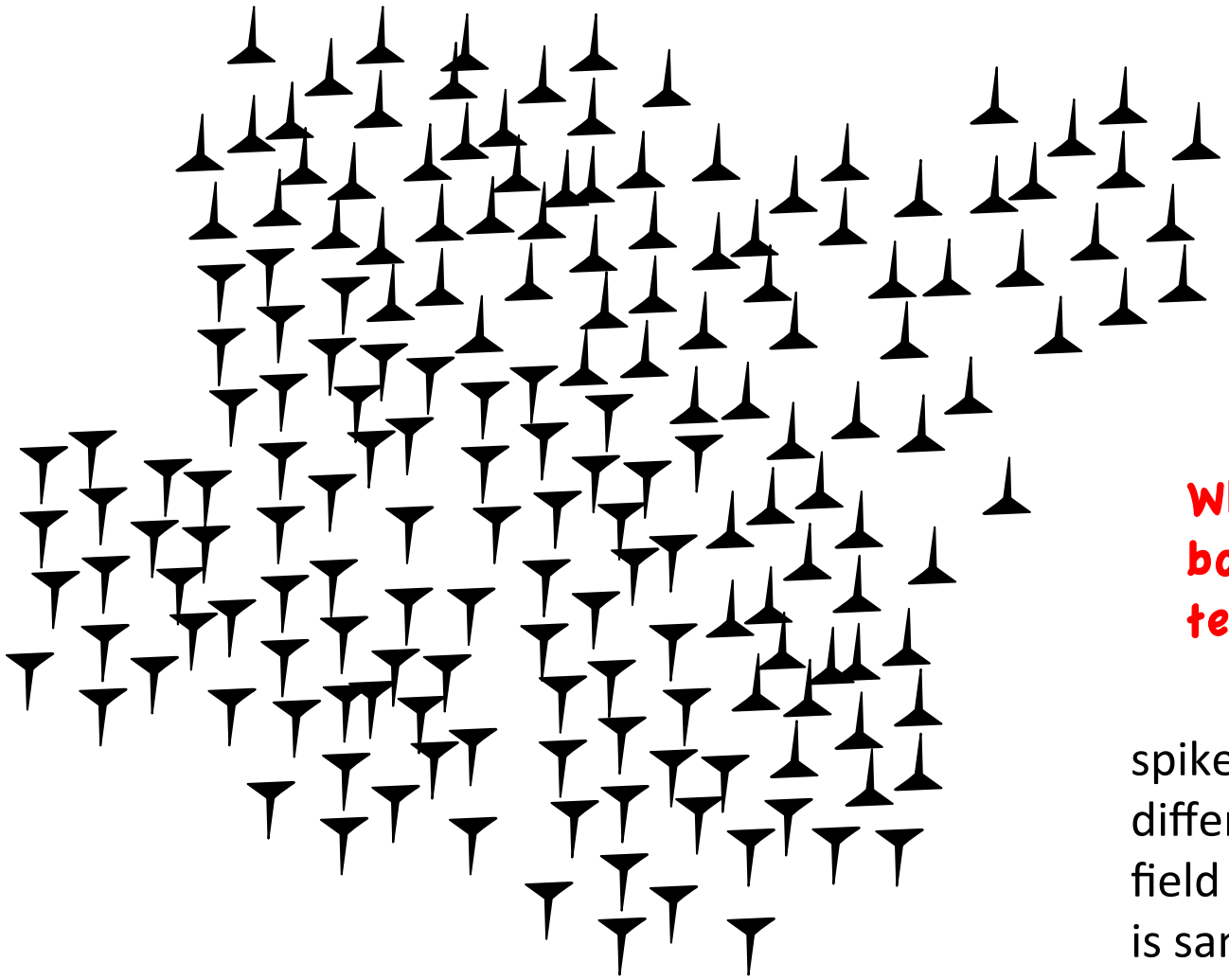
Drawbridge with Lady with Parasol by Vincent Van Gogh, pen and ink, 23.5 × 31 cm., 1888, Los Angeles County Museum

Fishing Boats at Saintes-Maries-de-la-Mer by Vincent Van Gogh, pen and ink and pencil, 24.4 × 31.9 cm Saint Louis Art Museum

Hard-to-discriminate texture pairs

- when low-level feature differences not present, we find it hard to discriminate between textures
- for design purposes, only basic texture differences should be used to divide space

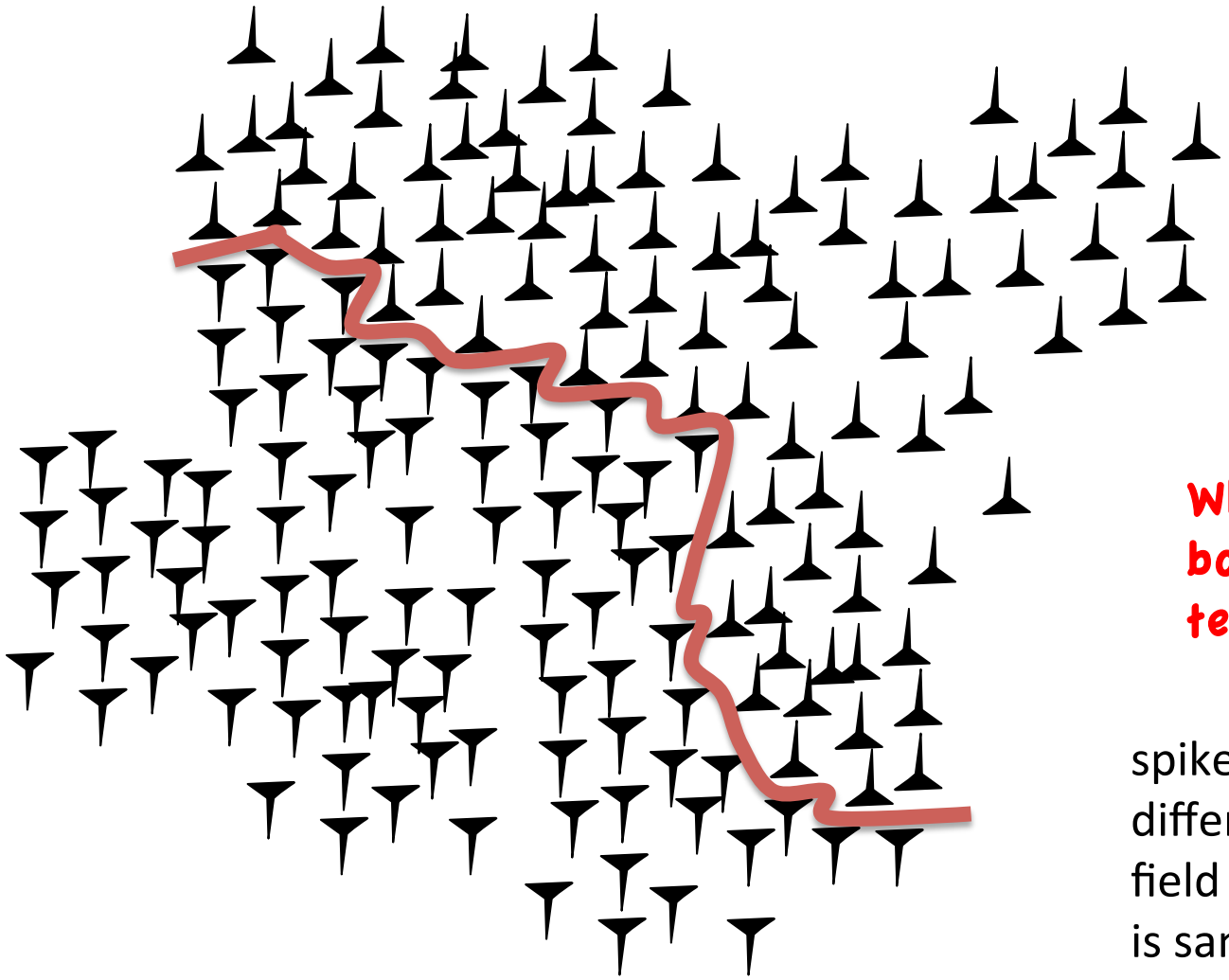
Hard-to-discriminate texture pairs



Where is the border between textures?

spikes orientated differently, but field of orientation is same

Hard-to-discriminate texture pairs



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Hard-to-discriminate texture pairs

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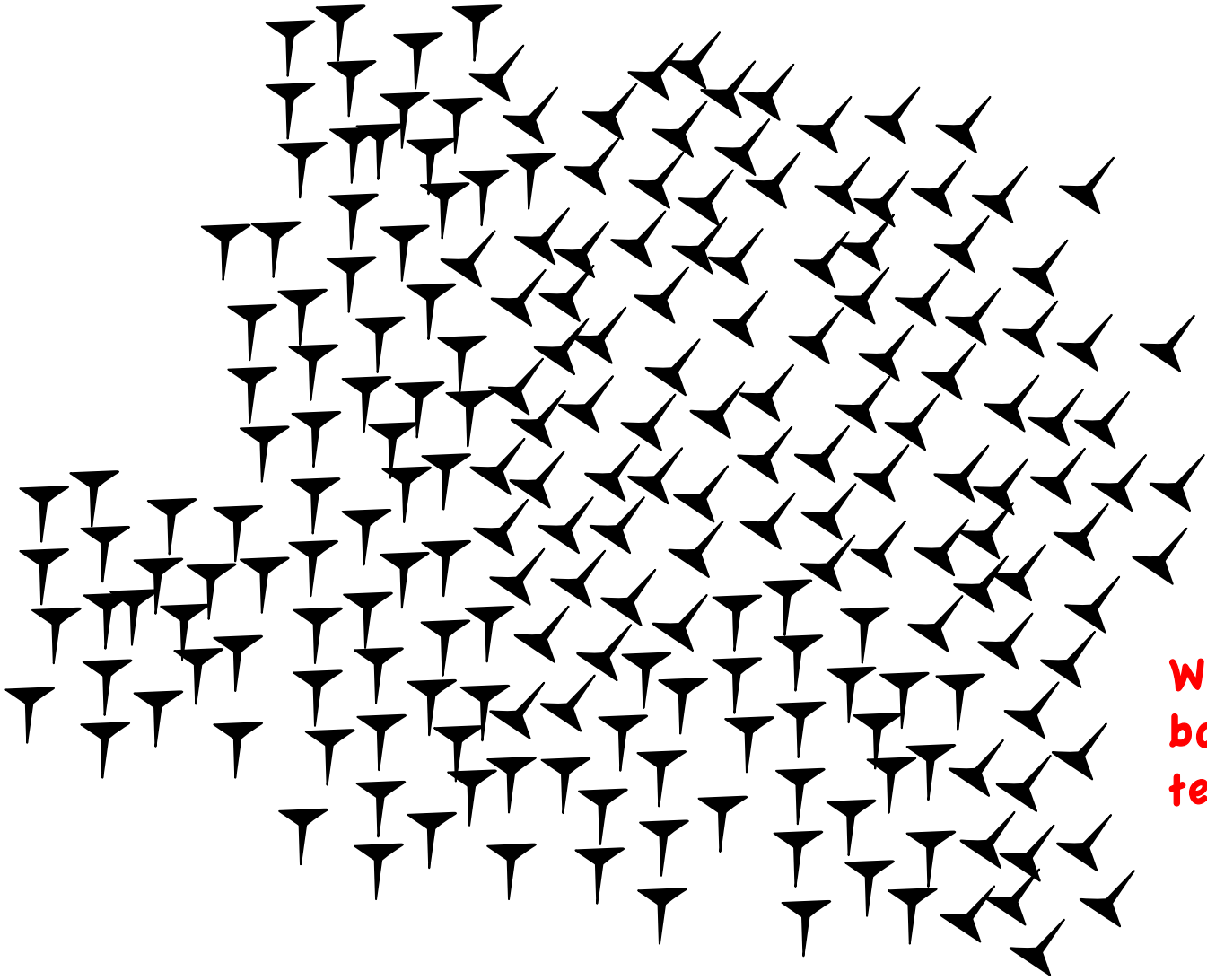
Compare:



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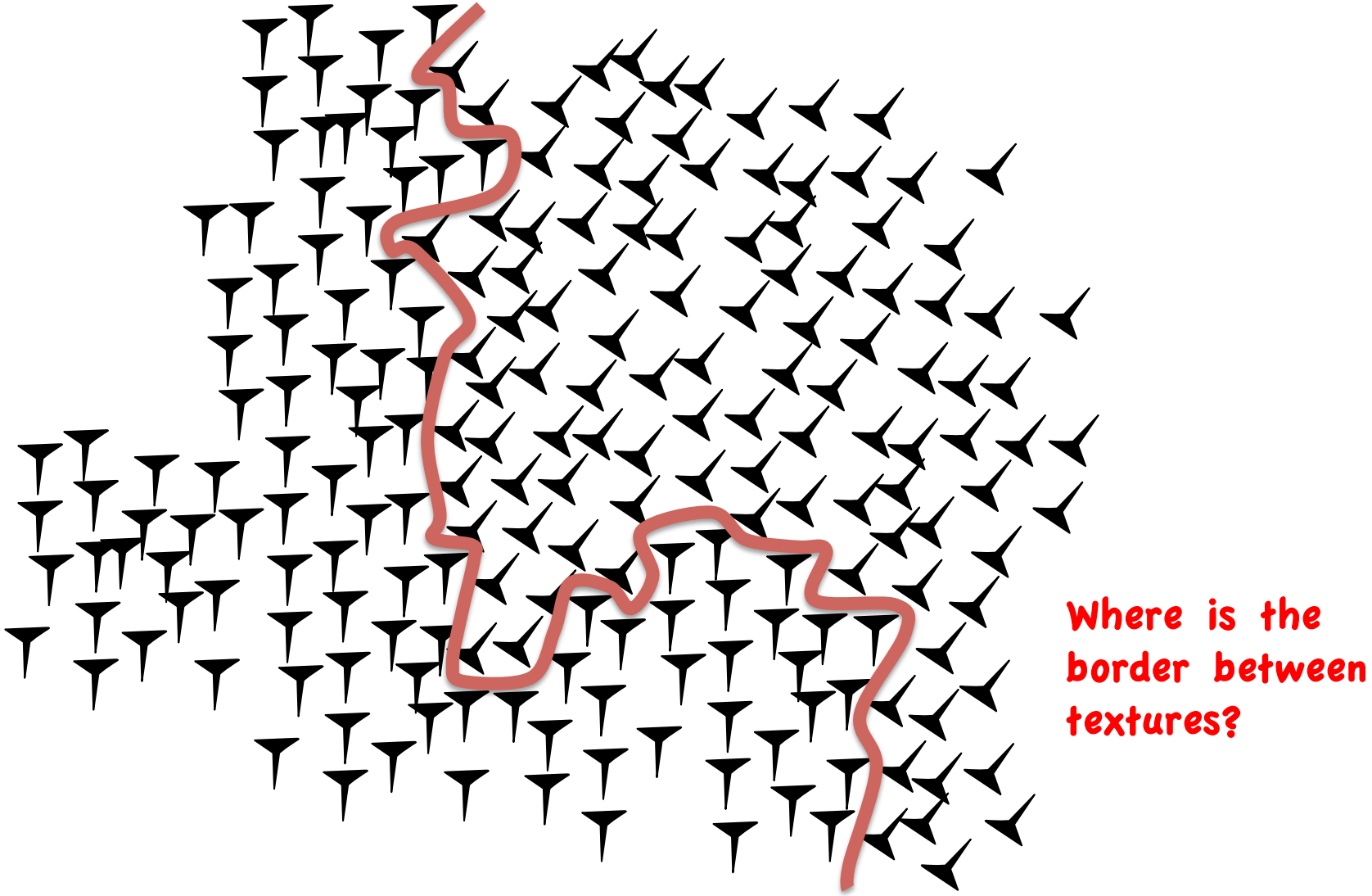
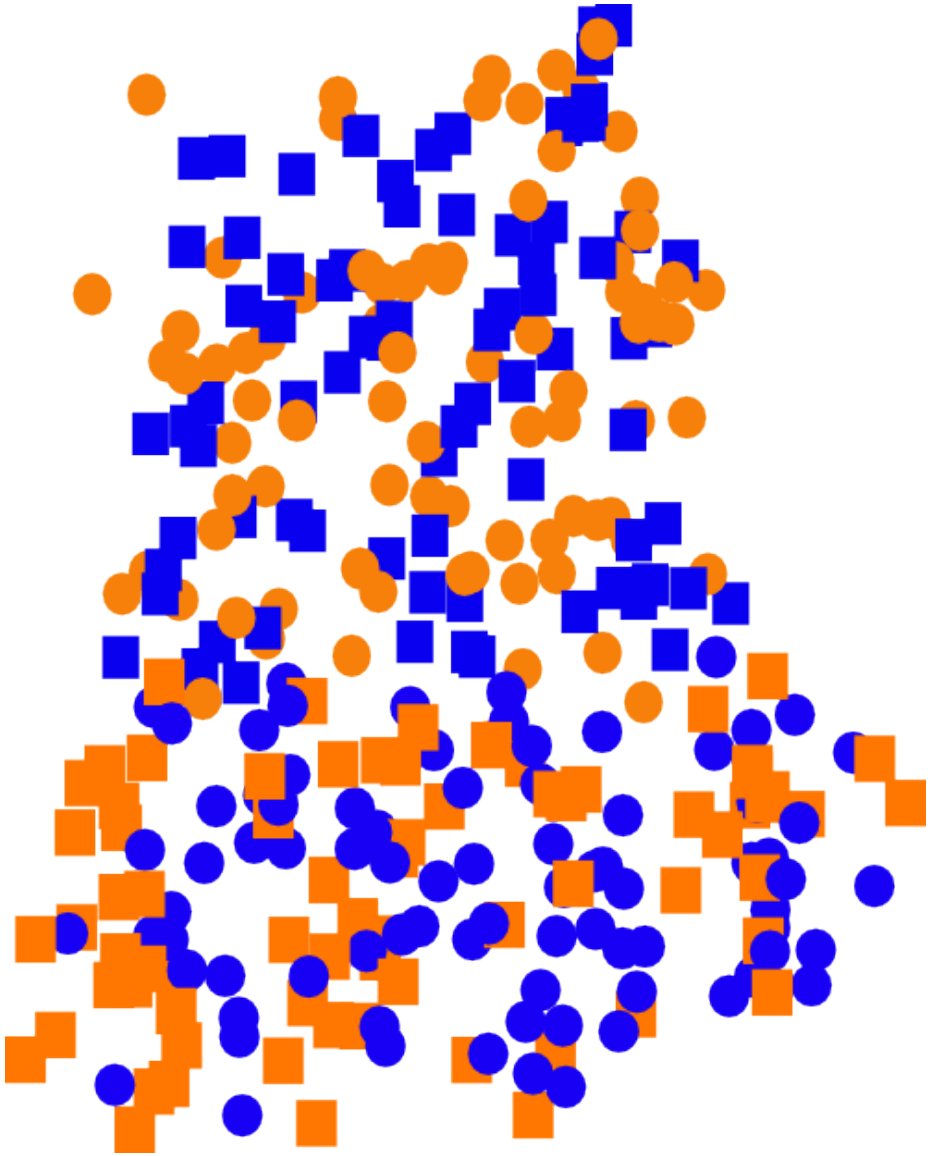
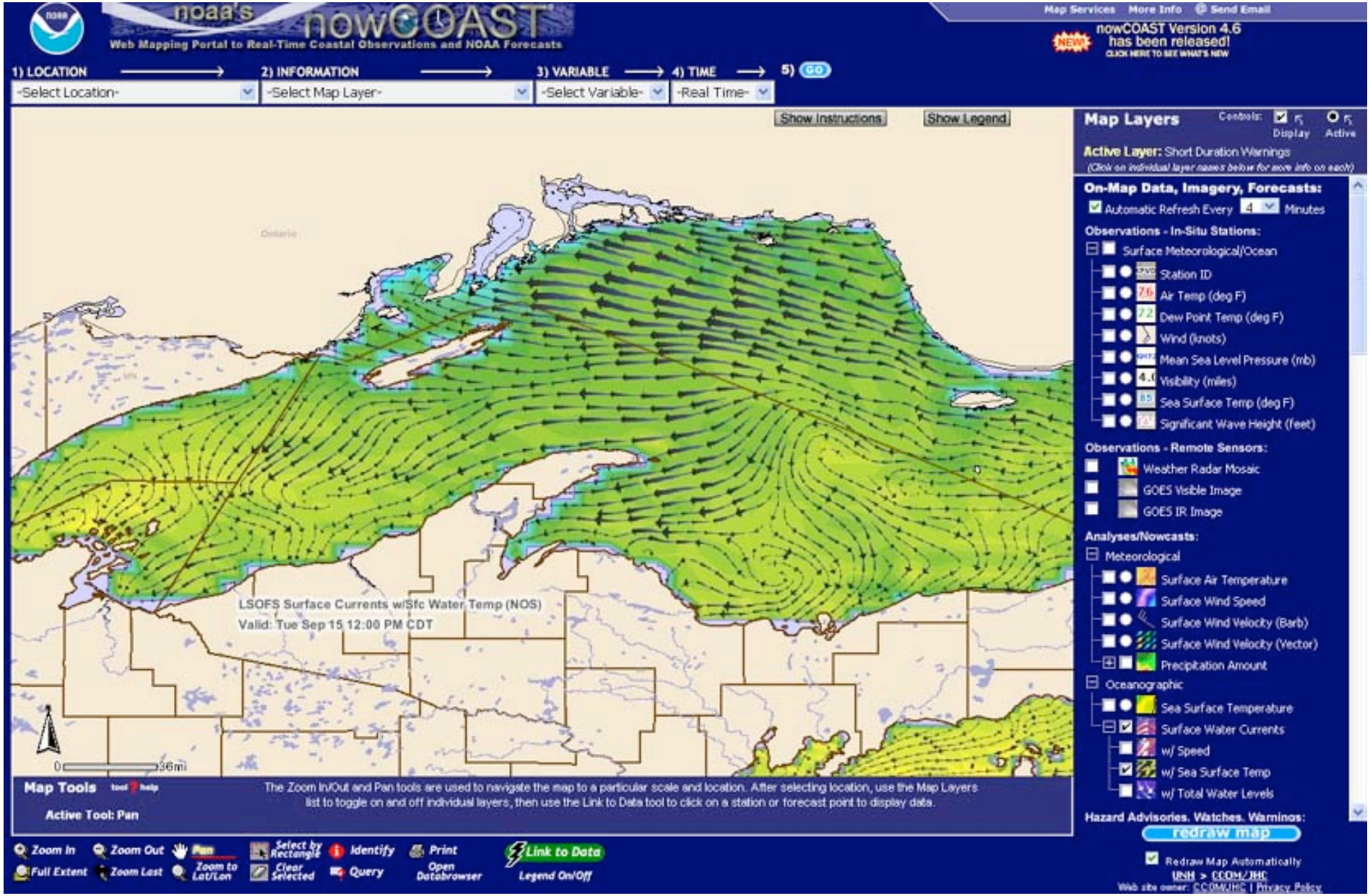


Hard-to-discriminate texture pairs

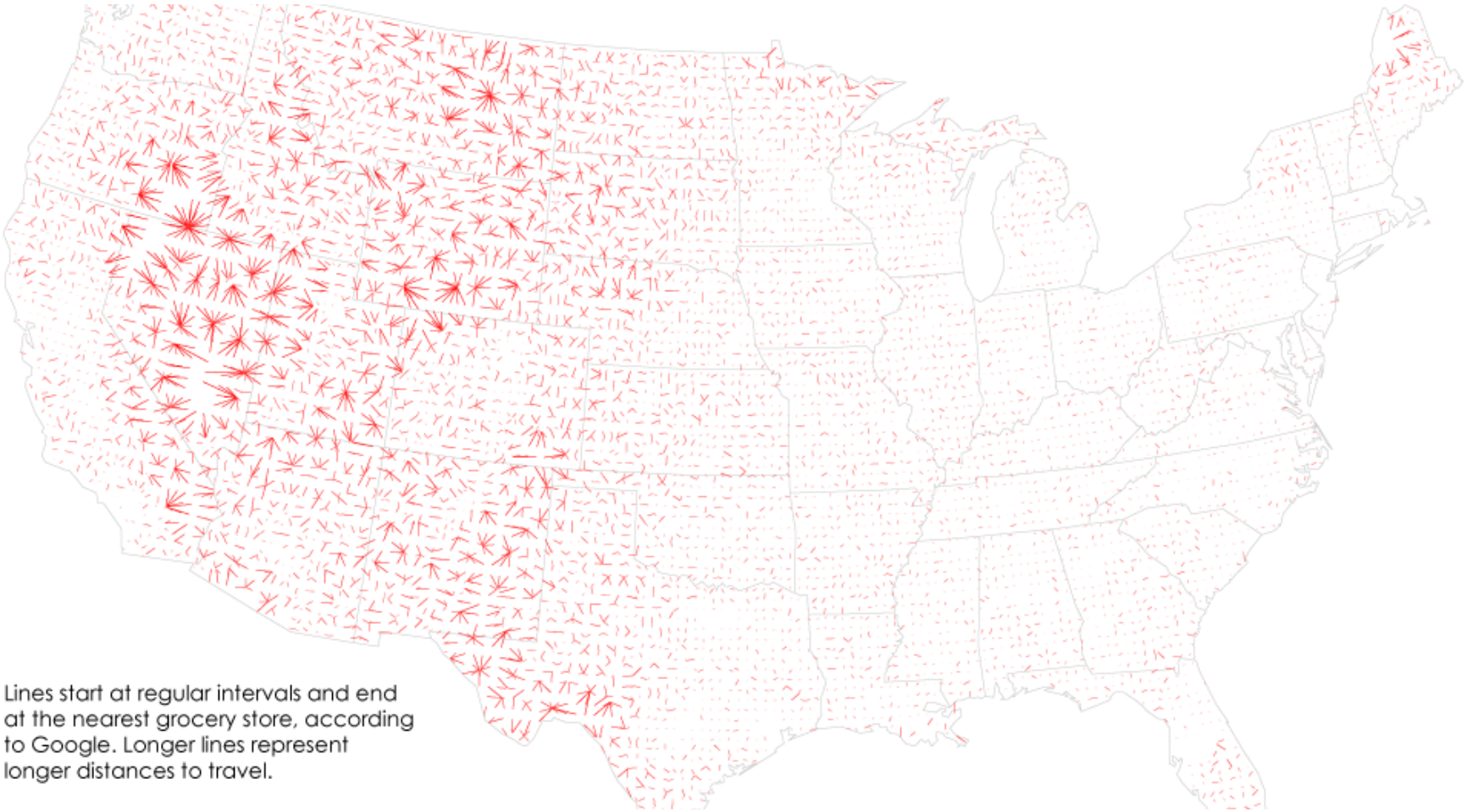


orange circles and blue squares versus blue circles and orange squares

Screenshot of nowCOAST Viewer, showing detailed view of the Lake Superior OFS Surface Water Currents. The background colors shown indicate Sea Surface Temperature.

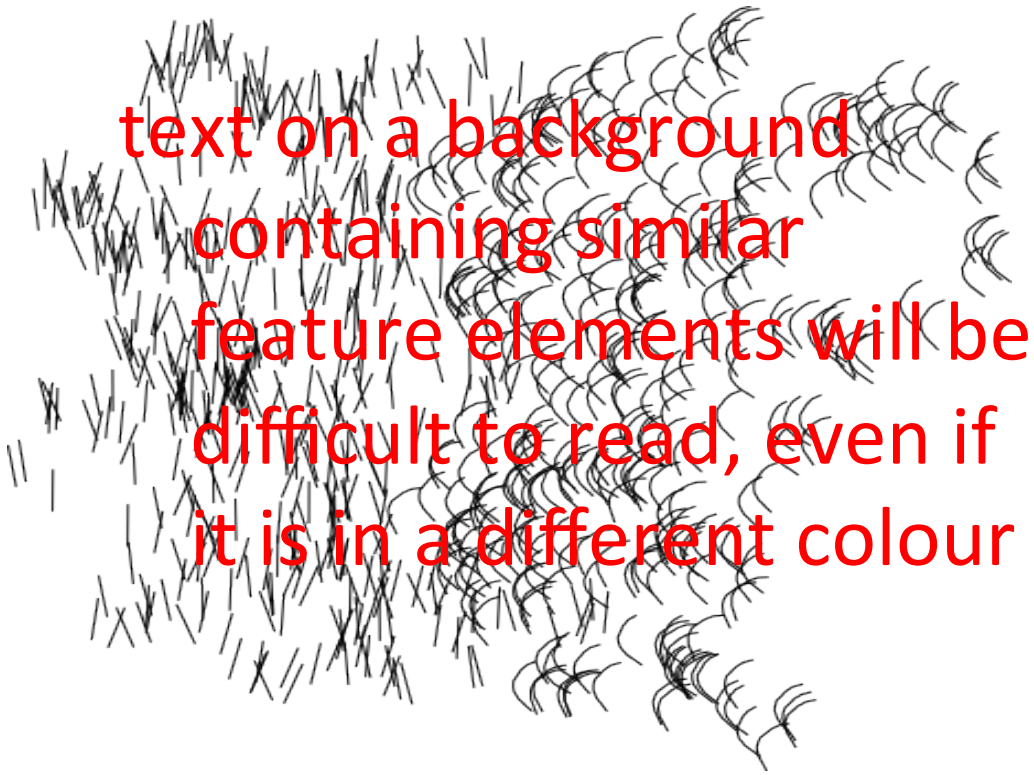


Distance to nearest grocery store

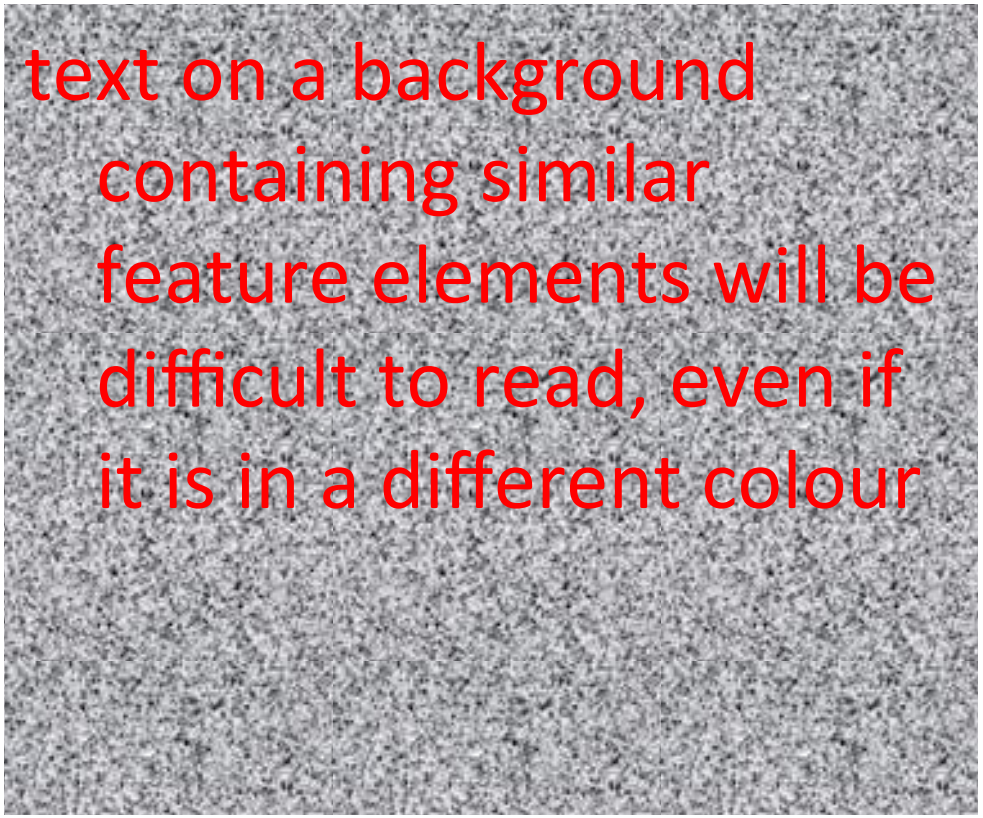


Lines start at regular intervals and end at the nearest grocery store, according to Google. Longer lines represent longer distances to travel.

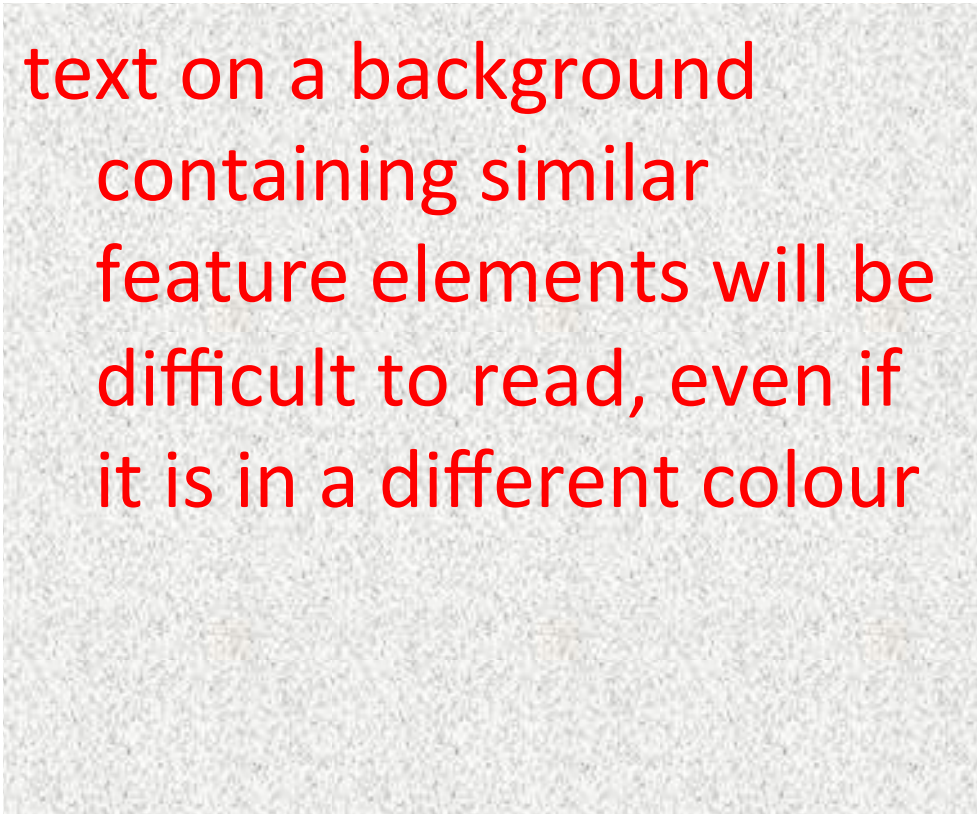
Interference



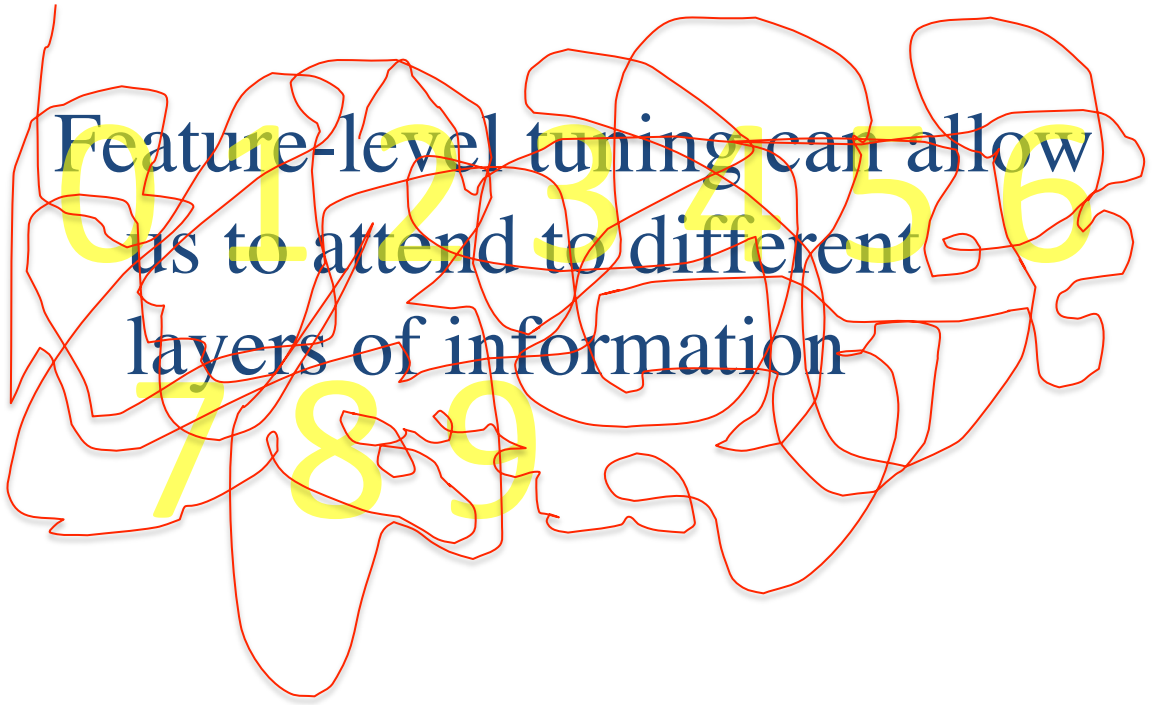
Interference: compare



Interference: compare 2



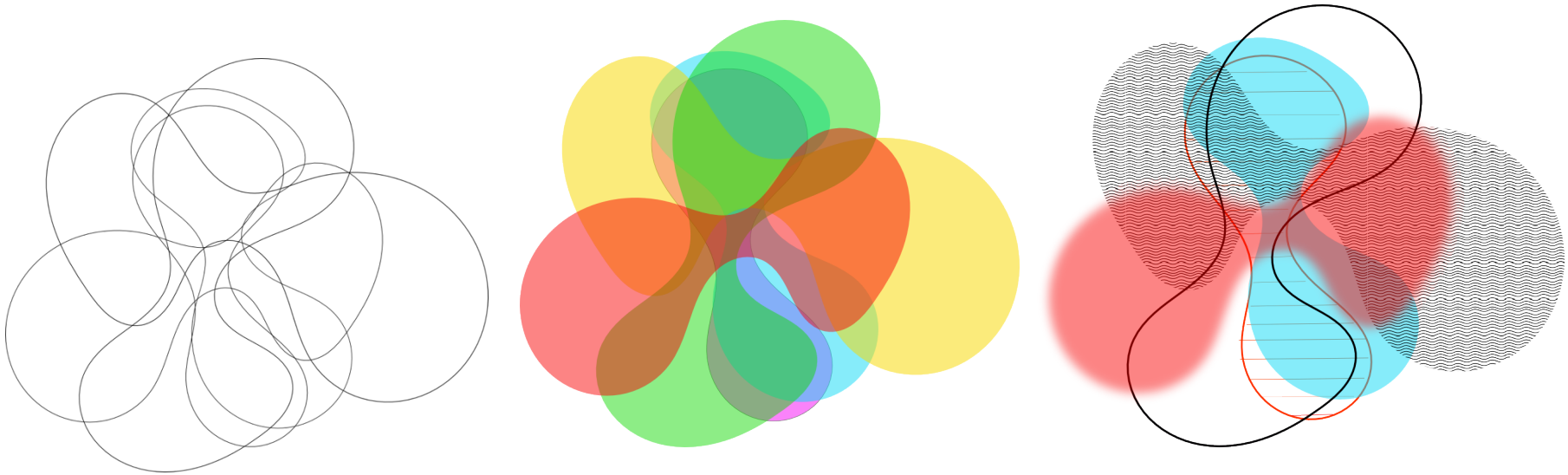
Feature-level tuning



Feature-level tuning for overlapping regions

- Representing overlapping regions is an interesting design problem
  - e.g. a map that shows both mean temperature, differing vegetation types etc.
  - Goal is to support variety of queries based on temperature zones, vegetation zones or both.
  - if different regions are display to be as distinct as possible in terms of simple features, the result will be easy to interpret

Feature-level tuning for overlapping regions: example



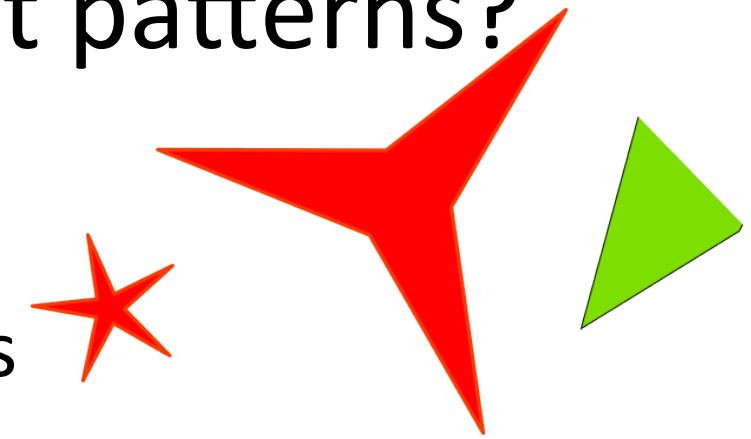
heterogeneous channel-based approach

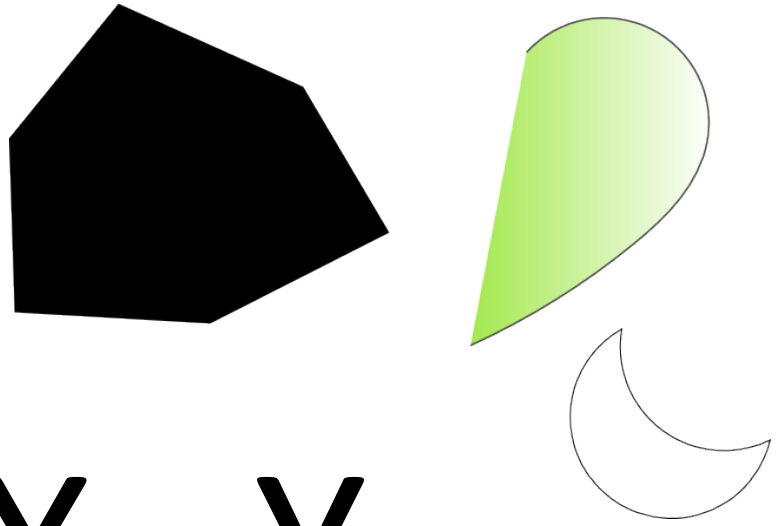
What are the best patterns?

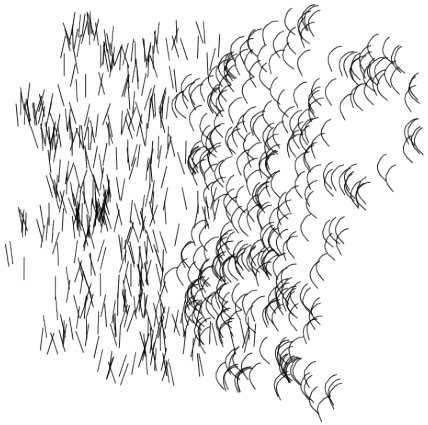
- The *what* pathway identifies patterns, which are increasingly complex the further we move up the hierarchy
- There is no current experiment that will determine which, of a possible infinite number, patterns a neuron responds to best
  - all researchers can do currently is find out by trial and error which patterns humans respond to well

What are the best patterns?

- spikes
- convexities and concavities
- boundaries between texture regions
- T and X junctions



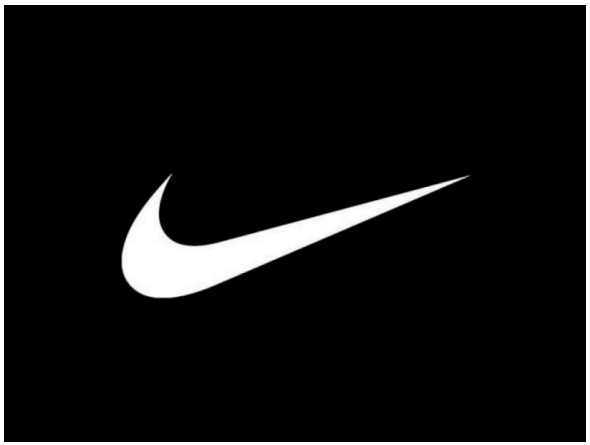




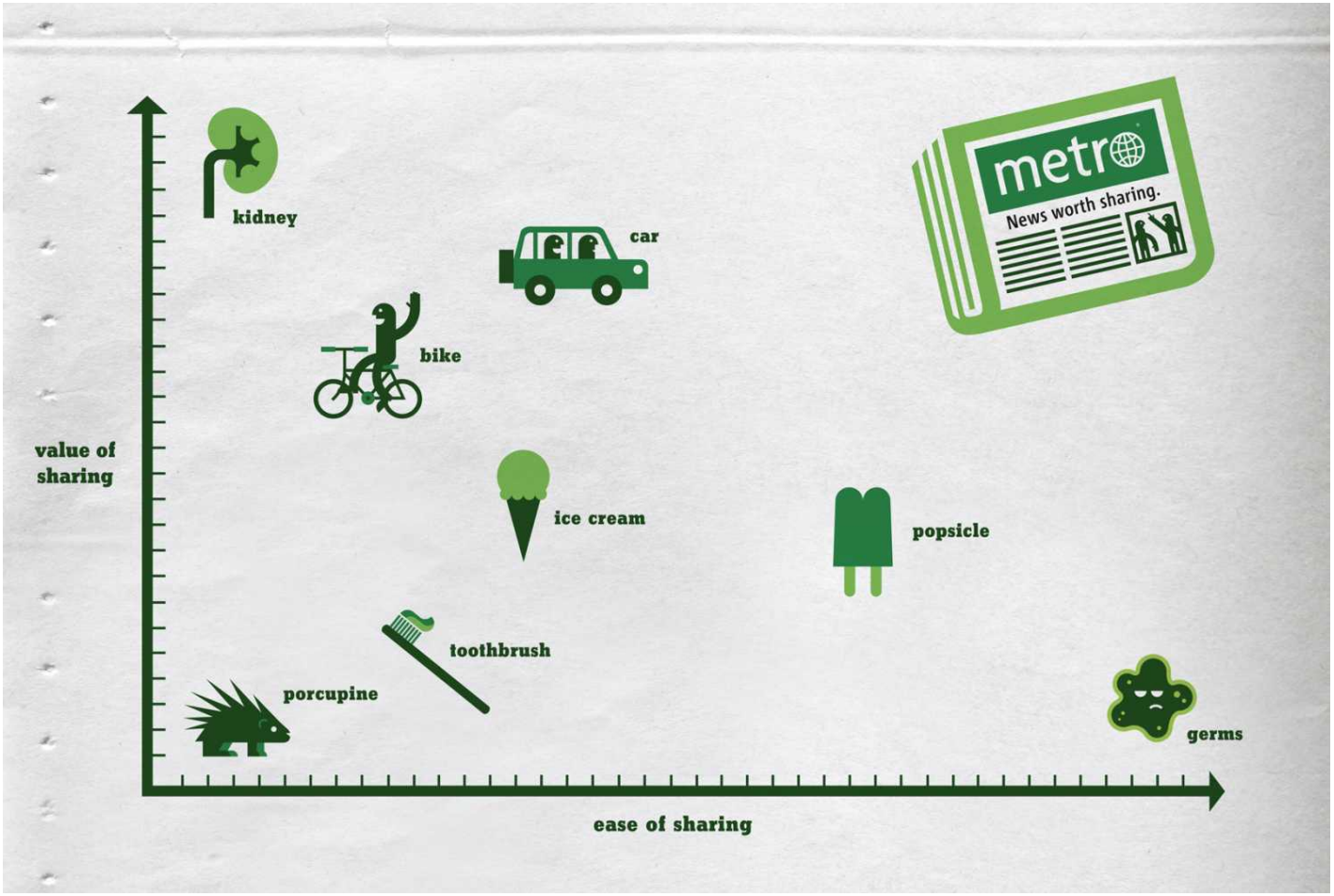
T X Y

Natural selection for symbols?

- spikes
- convexities and concavities
- boundaries between texture regions
- T and X junctions



Symbols



http://www.rethinkcanada.com

The importance of experience

- As we move up the “what” pathway to more complex patterns, the effects of individual experience become apparent
  - much of the training in V1 happens in babies
  - higher up the pathway is later life training

Meaning of patterns- Gestalt Laws

Proximity: items close together are grouped together.

Similarity: similar items are grouped together.

Connectedness: items connected are related.

Continuity: we are more likely to construct visual objects out of elements that are smooth and continuous.

Symmetry: symmetry connects items into entities.

Closure: a closed contour tends to be seen as an object. When an object is incomplete or a space is not completely enclosed we percieve the whole by filling in the missing information.

Relative size: smaller components of a patterns tend to be perceived as objects.

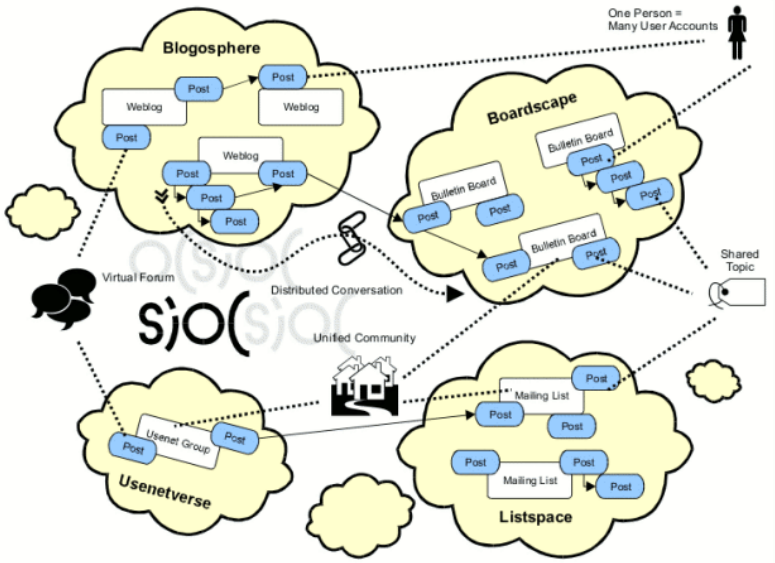
Figure and ground Effects: figure is that perceived as foreground, ground is behind the figure.

Rubin's Vase is a popular optical illusion used to illustrate differences in perception of figure-ground stimuli.

Figure source: "Introducing the Perception Process." Boundless Psychology. Boundless, 20 Aug. 2015

Semantic meaning of patterns
Basic patterns

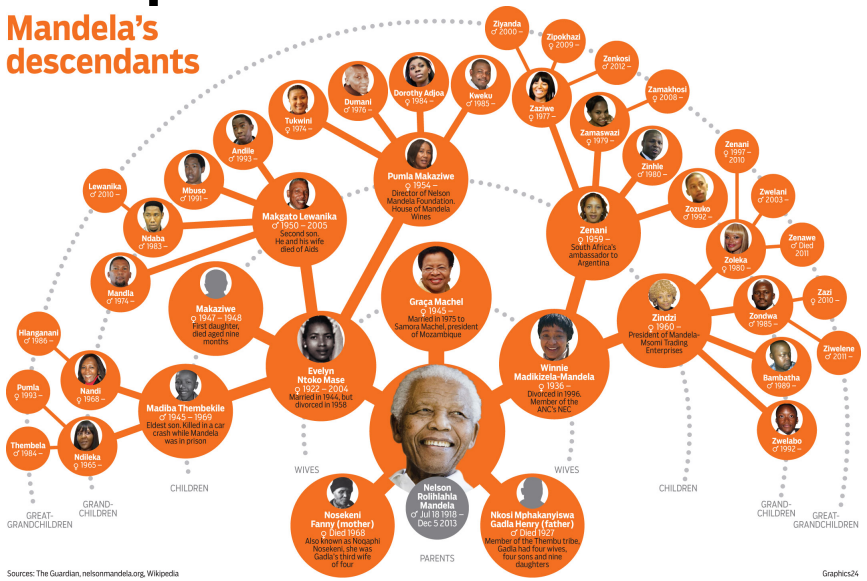
- small shapes with closed contour :
  - object, idea, entity, node
- Spacial ordered graphical objects:
  - related information or a sequence (left-to-right)
- Objects in proximity or with same colour/texture:
  - similar concepts, related information
- Size or height of object:
  - Magnitude, quantity, importance, 2D location

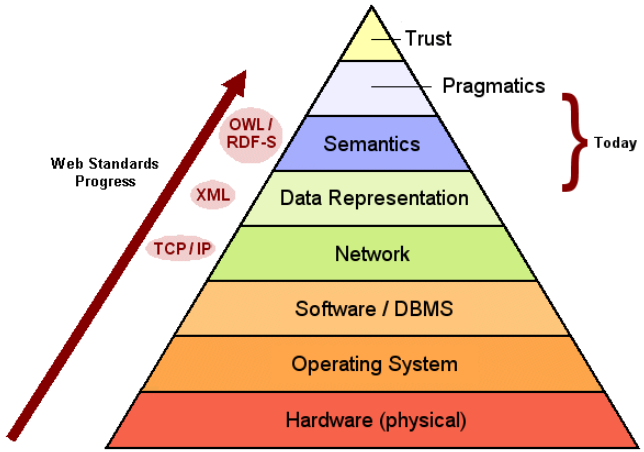


Creating connections between discussion clouds with SIOC

Semantic meaning of patterns
More complex patterns

- Shapes connected by contour:
  - related entities, path between entities
- Thickness of connecting contour:
  - strength of relationship
- Colour and texture of connecting contour:
  - type of relationship
- Shapes enclosed by a contour/ texture/colour:
  - contained entities, related entities
- Nested/partitioned regions:
  - hierarchical concepts
- Attached shapes:
  - parts of a structure





Visual Thinking

Visual Space

February 2016
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Depth

- Egocentric space consists of up-down, sideways and **towards-away** dimensions
- 2.5 dimensions
  - for every one of the **million brain pixels** recording up and sideways information, there is only, at best, **one point** of depth information
- depth cues are **pictorial** and **non-pictorial**

Depth

- When viewing a graphic, we simultaneously see the flat, 2D picture plane and the 3D picture space

Diego Rodríguez de Silva y **Velázquez, Las Meninas, c. 1656, oil on canvas, 125 1/4 x 108 5/8 in.** (Museo Nacional del Prado, Madrid)

Pictorial Depth Cues

- pictorial (or **monocular**) depth cues can be reproduced in a photograph or painting
  - defined by the projection of points on a plane
  - need only one eye to see them

Pictorial Depth Cues

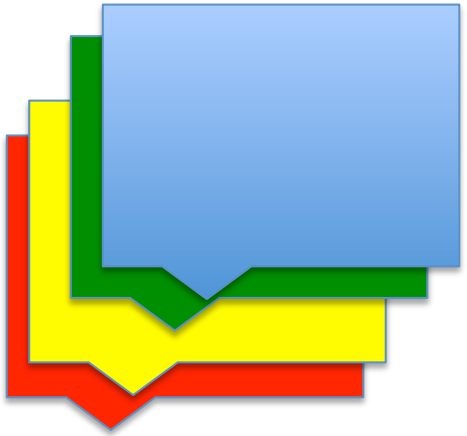
- pictorial depth cues do not have to be defined in an all-or-nothing fashion: they can be applied according to goals of design
  - choice is **not 2D or 3D**, but **which** of the depth cues **to apply**
  - each have unique properties that support different kinds of visual query

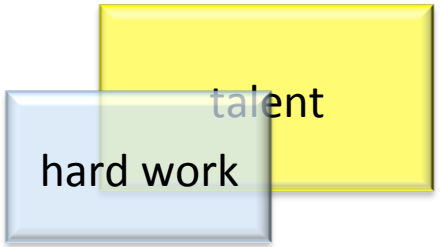
Pictorial Depth Cues: Occlusion

strongest depth cue

- if placed in competition with another, such as size constancy, occlusion wins

- objects near to us block or visually occlude objects further away.
- an object that occludes another appears closer



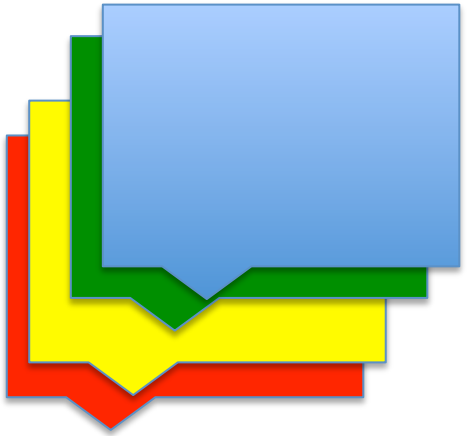


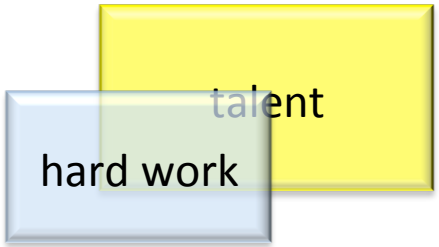
Pictorial Depth Cues: Occlusion

a **method** and **metaphor** for ranking ordered information

- most important partially occlude less important

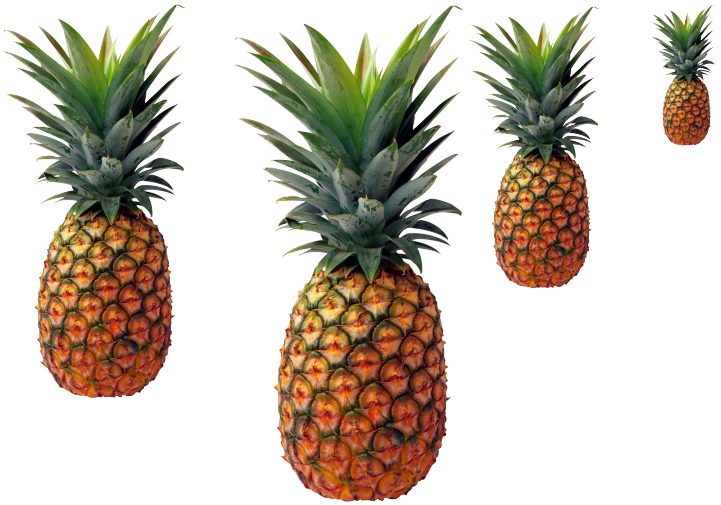
- **very important** to ensure that the occluded object can still be **identified**





Pictorial depth cues: Perspective

- **Size gradients**: more distant objects are smaller on the picture plane than similarly sized nearby objects
- visual metaphor for relative importance
  - advantage that less important information takes up less space



http://art.nmu.edu/

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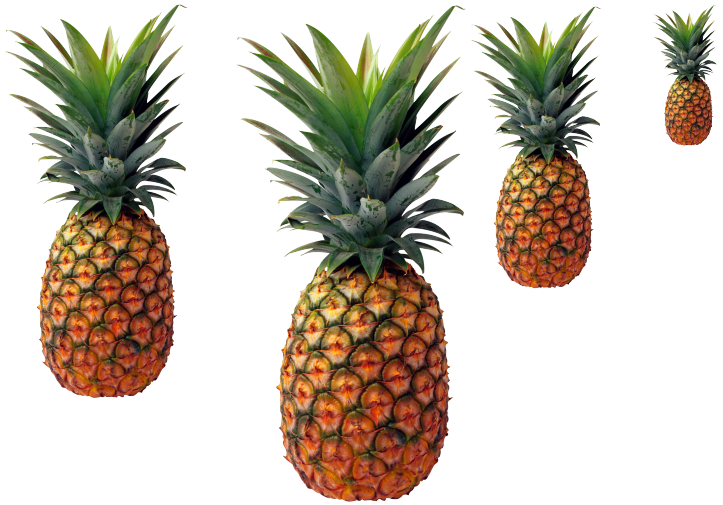

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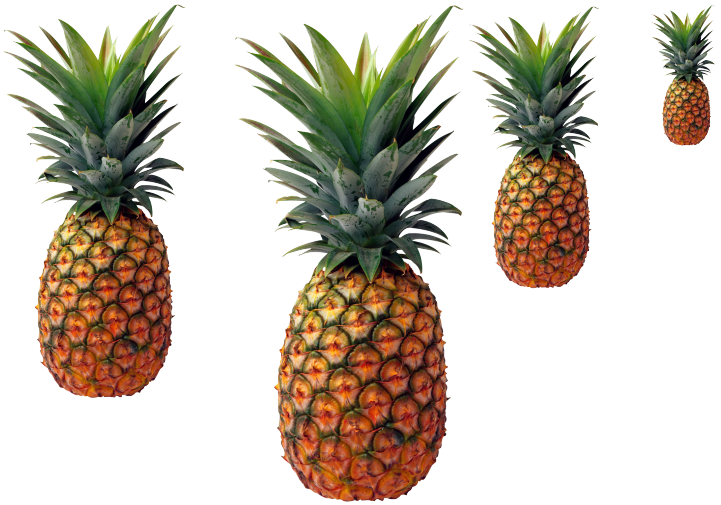


http://art.nmu.edu/

Pictorial depth cues: Perspective

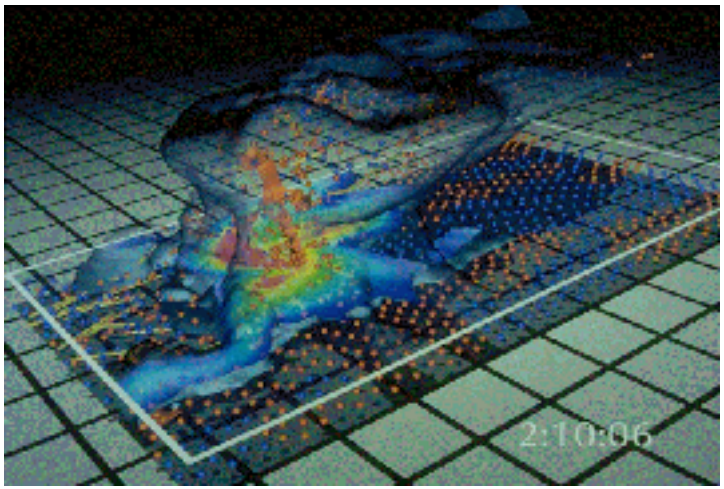
wordle tag cloud for
“Biological components of sex differences in color preference
Anya C. Hurlbert and Yazhu Ling

Pictorial depth cues: Perspective

- **Texture gradients**: texture elements reduce in size and increase in density with distance
- Provide a size reference for objects
- but usually less effective than a grid for making size judgements
- also, fine textures usually not reproduced on computer displays

Pictorial depth cues: Linear perspective

- Projections of parallel lines converge on the picture plane
- grid of parallel lines used often in 3D layouts of scientific objects to provide a reference plane for layout and size measurement

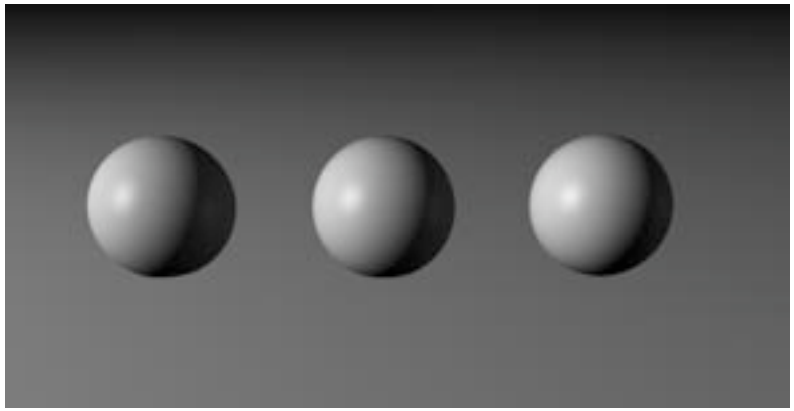


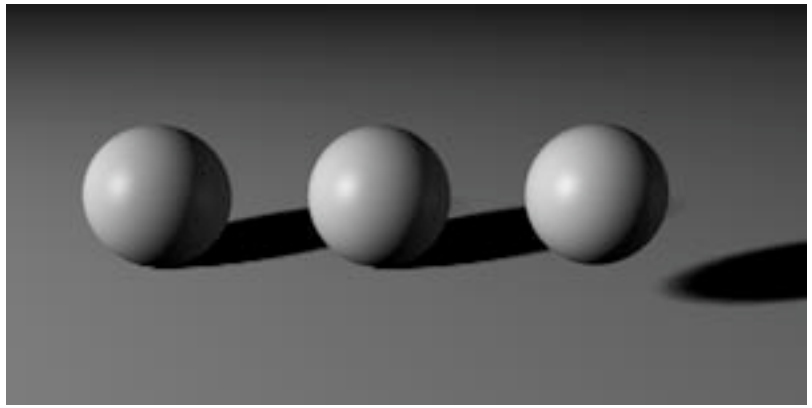
visualization of a severe supercell thunderstorm

Pictorial depth cues: Shading and Cast Shadows

- surface of objects reflect more or less light depending on how they are oriented to a light source

http://art.nmu.edu/





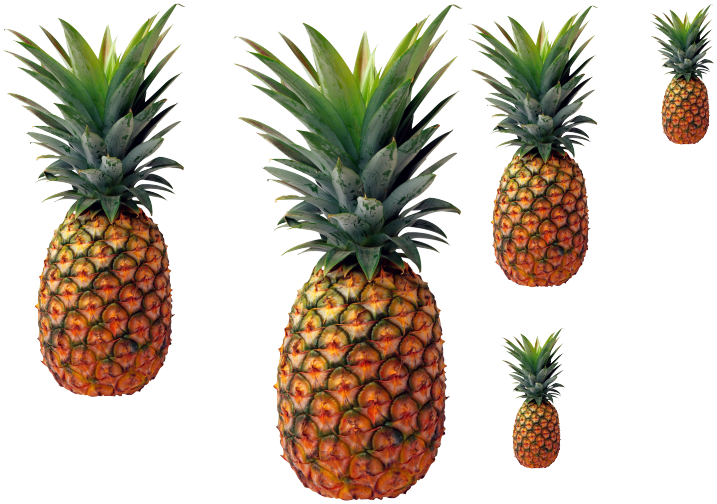
- The shadow cast by one object on another provides information about the distance between them

Pictorial depth cues: Dropped shadows

Pictorial depth cues: Dropped shadows

Pictorial depth cues: Height on the picture plane

- objects higher up the visual field are generally seen as further away



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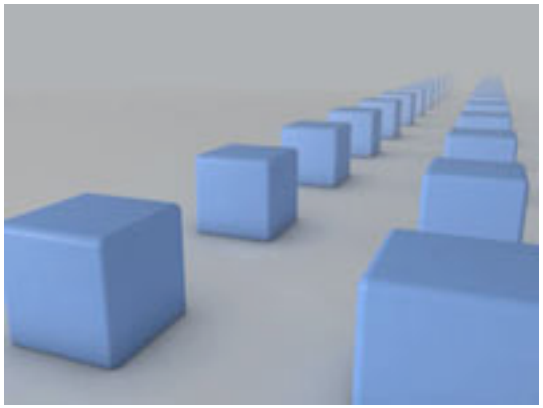
Georges Seurat
A Sunday Afternoon on the Island of La Grande Jatte
1884-86, oil on canvas

Pictorial depth cues: Depth of focus

- The human eye focuses objects at a specific distance:
  - objects closer or further away are blurred
  - degree of blur can be used to direct attention



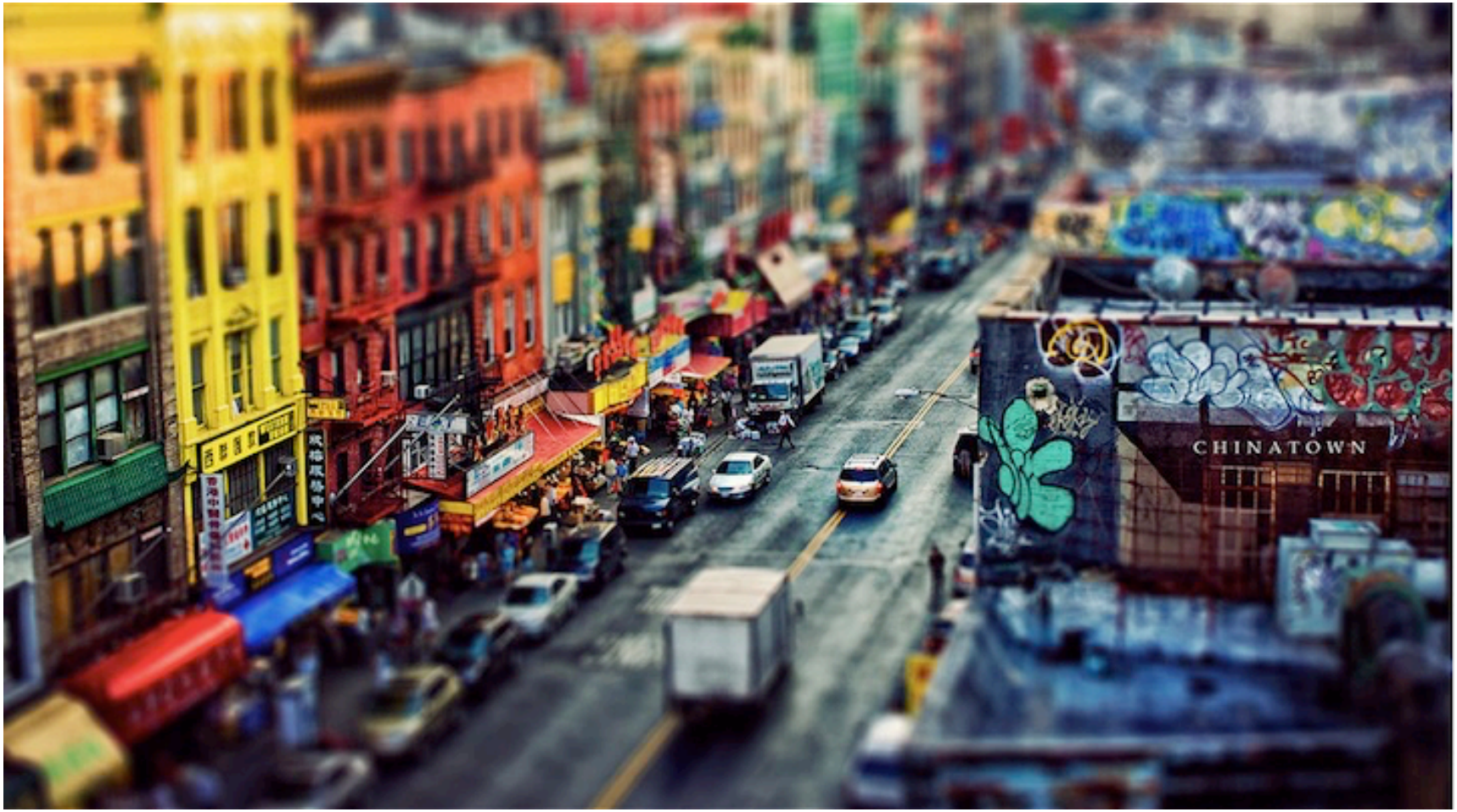
Depth of focus

- Miniature faking, also known as diorama effect or diorama illusion, is a process in which a photograph of a life-size location or object is made to look like a photograph of a miniature scale model.
- Blurring parts of the photo simulates the shallow depth of field normally encountered in close-up photography, making the scene seem much smaller than it actually is.

Digitally blurred miniature fake of Jodhpur

Original photo of Jodhpur

Depth of focus



Pictorial depth: reference to known objects

- objects of known size are a reference against which other objects are judged
  - absolute size
  - knowledge-based, but one of the most important cues to distance

We see the duck as closer than the elephant

http://art.nmu.edu/

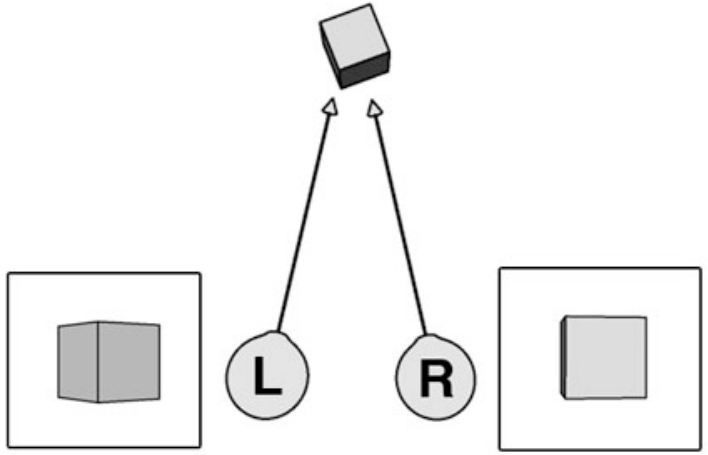
Pictorial depth: Degree of contrast

- Because air and water are not completely transparent, the contrast between an object and its background is reduced as distance increases
- “atmospheric perspective"

http://art.nmu.edu/cognates/concepts/175_depthcues.html

Non-pictorial depth: stereoscopic depth

- Not captured in a static image
- V1 has mechanisms to extract small differences in images on two eyes to get distance information
- stereoscopic information is used for guiding our hands
- for objects at nearly the same depth

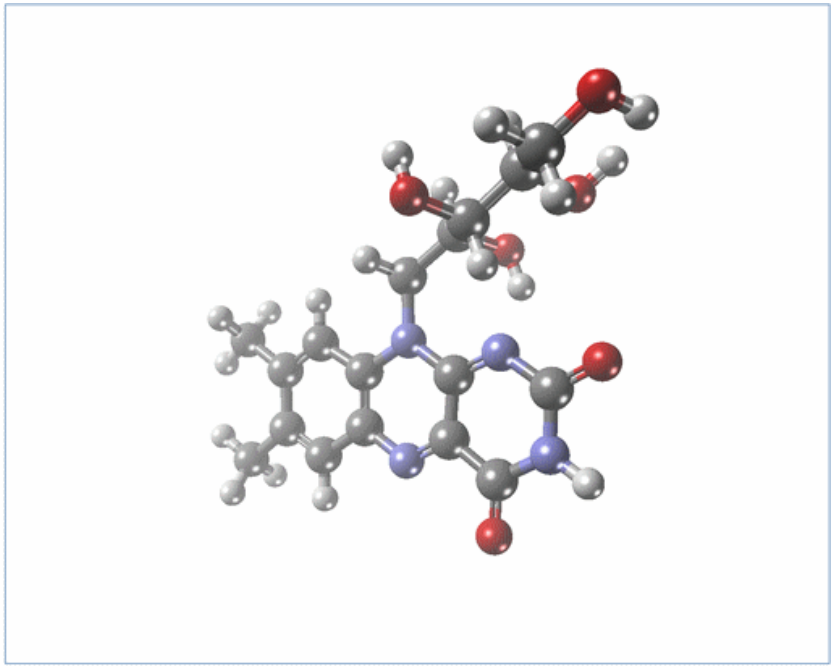


The diagram indicates a left and right eye. Both eyes converge on a box but due to retinal disparity, the angle of viewing is slightly different for each eye. The brain combines the two images to create the perception of a three-dimensional object.

Non-pictorial depth: stereoscopic depth

Non-pictorial depth: depth from motion

- better depth from steropsis
- brain takes advantage of series of views to interpret depth information

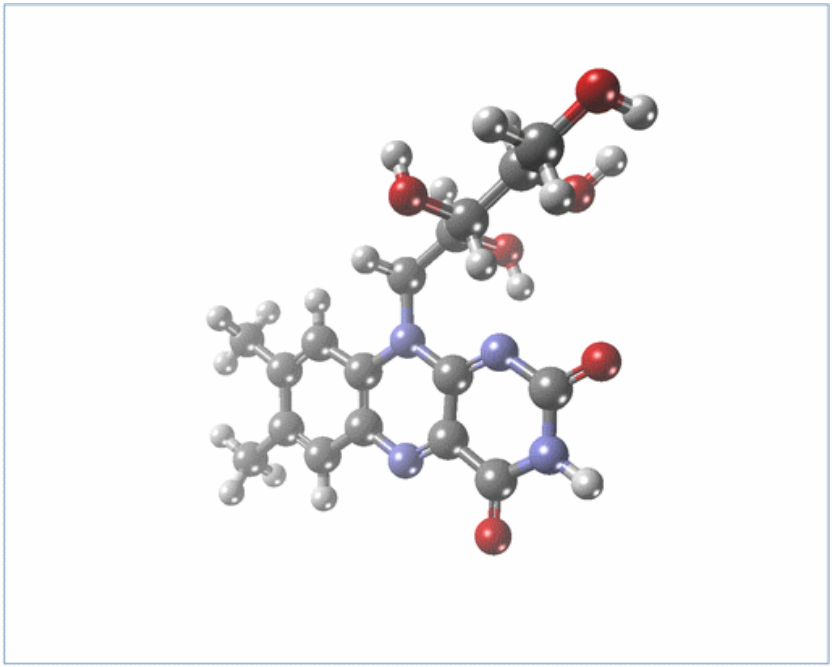


2.5 design

- treat depth very differently from other two dimensions:
  - depth cues used selectively to support design goals
  - objects laid out with minimum of occlusions – minimize depth
  - ensure critical information not occluded – use transparency where necessary
  - display text in the image plane

2D or 3D?

- when deciding whether as display should be 2D or 3D, the nature of what is displayed is very important:
  - some data already has 3D spatial properties
    - architectural designs and physical and biological data



2D or 3D?

- many other kinds of data are not inherently spatial
    - business statistics, social networks, abstract concepts
- some people have tried to use three dimensional representations for these, with the justification that, as we live in a 3D world, 3D must be better than 2D

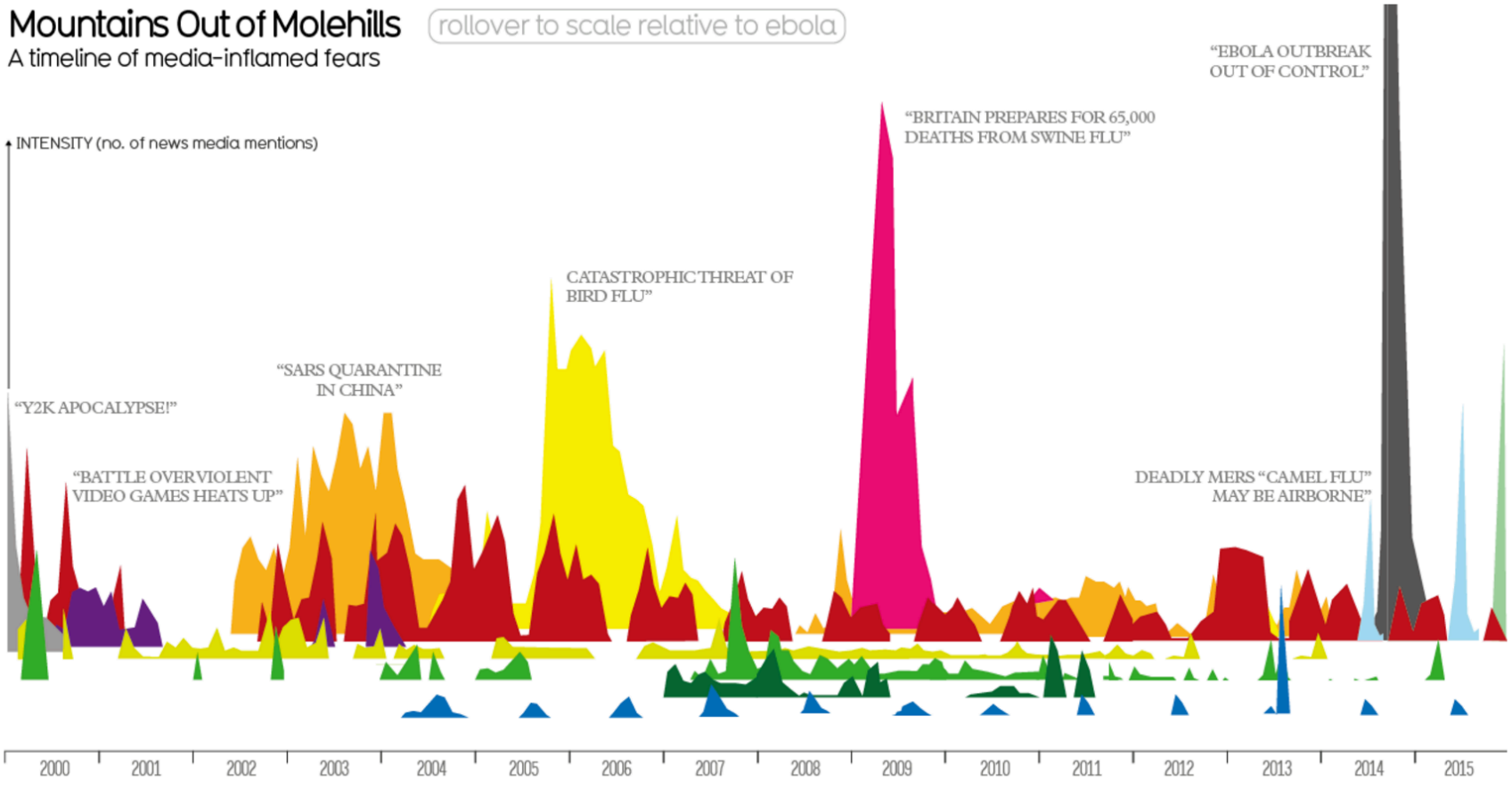
2D or 3D?

- BUT – we don't perceive 3 dimensions
  - 2.5D or, more realistically, 2.05 D
- The cost of getting a good viewpoint in 3D is almost always higher than clicking to follow a hypertext link or zooming in 2 dimensions
- eye movements are the lowest cognitive cost method we have for getting information on our environment

Mountains Out of Molehills

rollover to scale relative to ebola

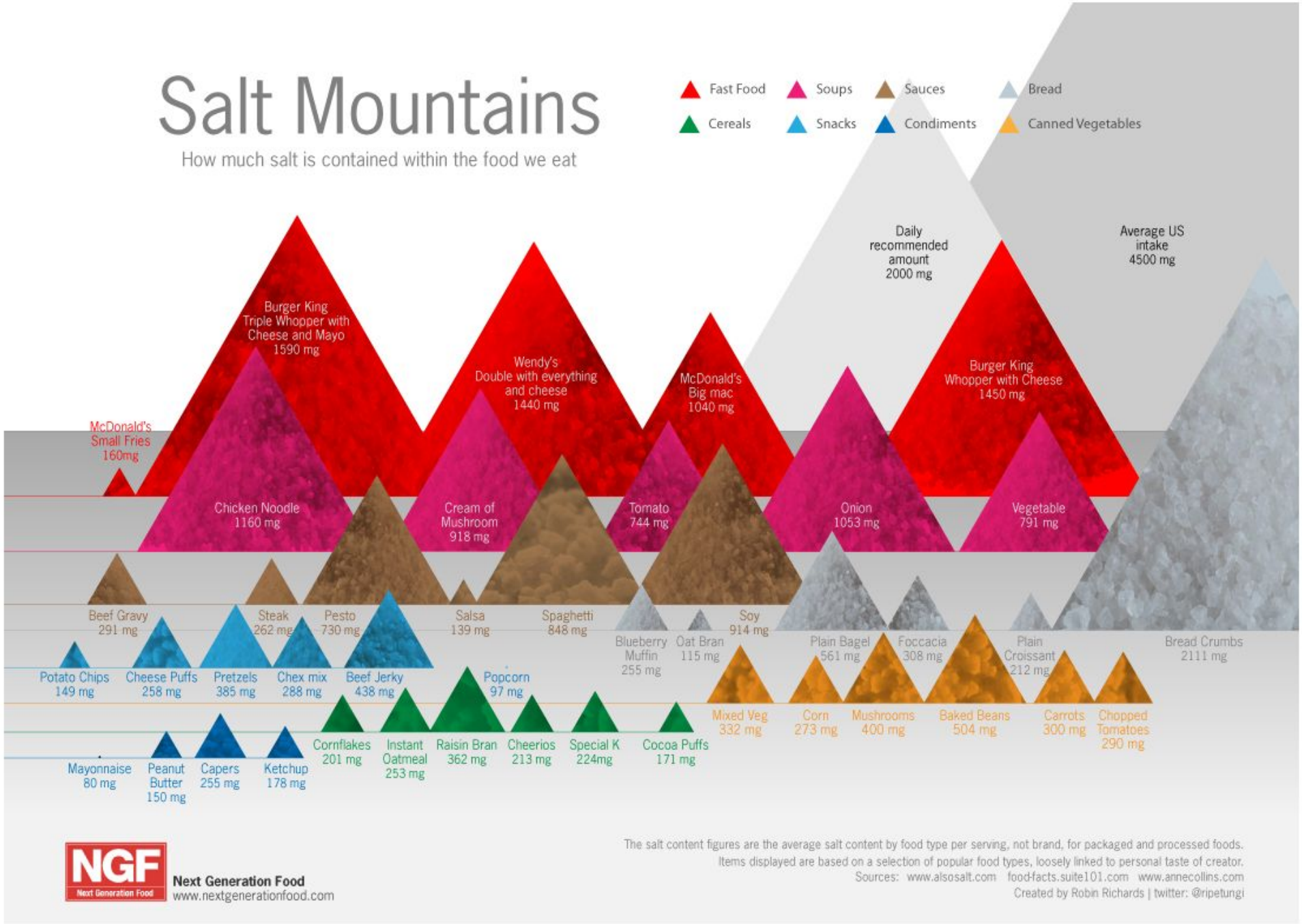
A timeline of media-inflamed fears



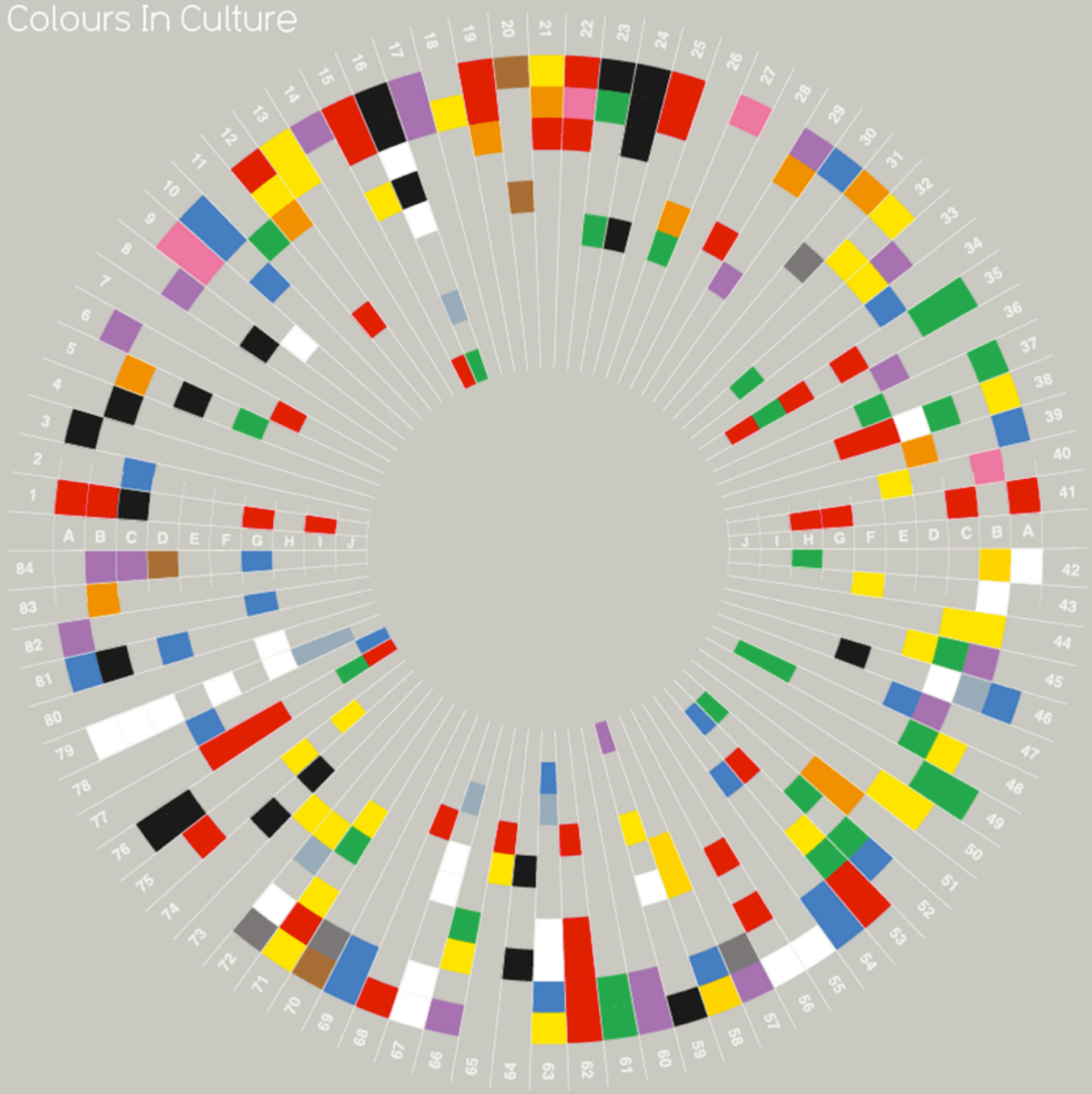
MILLENNIUM BUG | VIOLENT VIDEO GAMES | VACCINES & AUTISM | MAD COW DISEASE | ASTEROIDS | SARS | KILLER WASPS | BIRD FLU | SWINE FLU | CELL PHONES & TUMOURS | EBOLA | MERS | ZIKA

design & concept: David McCandless informationisbeautiful.net

source: Googe Trends, Googe News Timeline // data retrieved 31st Dec 2015


Salt Mountains
How much salt is contained within the food we eat
Fast Food
Soups
Sauces
Bread
Cereals
Snacks
Condiments
Canned Vegetables
Daily recommended amount 2000 mg
Average US intake 4500 mg
Burger King Triple Whopper with Cheese and Mayo 1590 mg
Wendy's Double with everything and cheese 1440 mg
McDonald's Big mac 1040 mg
Burger King Whopper with Cheese 1450 mg
McDonald's Small Fries 160mg
Chicken Noodle 1160 mg
Cream of Mushroom 918 mg
Tomato 744 mg
Onion 1053 mg
Vegetable 791 mg
Beef Gravy 291 mg
Steak 262 mg
Pesto 730 mg
Salsa 139 mg
Spaghetti 848 mg
Soy 914 mg
Blueberry Muffin 255 mg
Oat Bran 115 mg
Plain Bagel 561 mg
Foccacia 308 mg
Plain Croissant 212 mg
Bread Crumbs 2111 mg
Potato Chips 149 mg
Cheese Puffs 258 mg
Pretzels 385 mg
Chex mix 288 mg
Beef Jerky 438 mg
Popcorn 97 mg
Mixed Veg 332 mg
Corn 273 mg
Mushrooms 400 mg
Baked Beans 504 mg
Carrots 300 mg
Chopped Tomatoes 290 mg
Mayonnaise 80 mg
Peanut Butter 150 mg
Capers 255 mg
Ketchup 178 mg
Cornflakes 201 mg
Instant Oatmeal 253 mg
Raisin Bran 362 mg
Cheerios 213 mg
Special K 224mg
Cocoa Puffs 171 mg
NGF
Next Generation Food
Next Generation Food
www.nextgenerationfood.com
The salt content figures are the average salt content by food type per serving, not brand, for packaged and processed foods.
Items displayed are based on a selection of popular food types, loosely linked to personal taste of creator.
Sources: www.alsosalt.com food-facts.suite101.com www.annecollins.com
Created by Robin Richards | twitter: @ripetungi

Colours In Culture



A Western / American	1 Anger	19 Desire
B Japanese	2 Art / Creativity	20 Earthy
C Hindu	3 Authority	21 Energy
D Native American	4 Bad Luck	22 Erotic
E Chinese	5 Balance	23 Eternity
F Asian	6 Beauty	24 Evil
G Eastern European	7 Calm	25 Excitement
H Muslim	8 Celebration	26 Family
I African	9 Children	27 Femininity
J South American	10 Cold	28 Fertility
	11 Compassion	29 Flamboyance
	12 Courage	30 Freedom
	13 Cowardice	31 Friendly
	14 Cruelty	32 Fun
	15 Danger	33 God
	16 Death	34 Gods
	17 Decadence	35 Good Luck
	18 Deceit	36 Gratitude

37 Growth	55 Luxury	73 Royalty
38 Happiness	56 Marriage	74 Self-cultivation
39 Healing	57 Modesty	75 Strength
40 Healthy	58 Money	76 Style
41 Heat	59 Mourning	77 Success
42 Heaven	60 Mystery	78 Trouble
43 Holiness	61 Nature	79 Truce
44 Illness	62 Passion	80 Trust
45 Insight	63 Peace	81 Unhappiness
46 Intelligence	64 Penance	82 Virtue
47 Intuition	65 Power	83 Warmth
48 Religion	66 Personal power	84 Wisdom
49 Jealousy	67 Purity	
50 Joy	68 Radicalism	
51 Learning	69 Rational	
52 Life	70 Reliable	
53 Love	71 Repels Evil	
54 Loyalty	72 Respect	

Yellow Grey
Gold Silver

David McCandless & AlwaysWithHonor.com // v1.0 // Apr 09 // InformationIsBeautiful.net

source: Pantone, ColorMatters & web sources