

Information Visualization

Marks & Channels

Tamara Munzner

Department of Computer Science
University of British Columbia

Lect 4/5, 16/21 Jan 2020

<https://www.cs.ubc.ca/~tmm/courses/436V-20>

Exercise: Two numbers

9 and 26

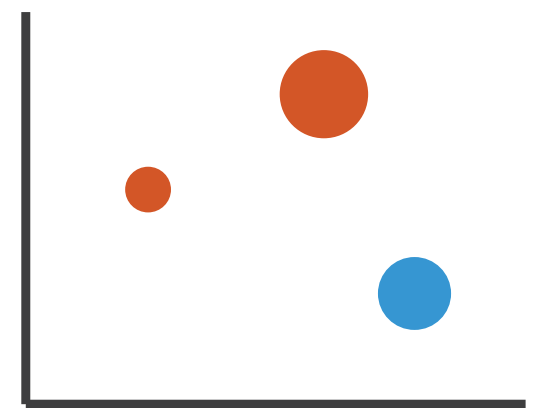
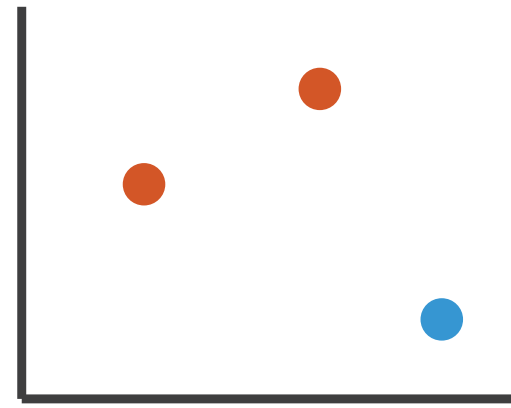
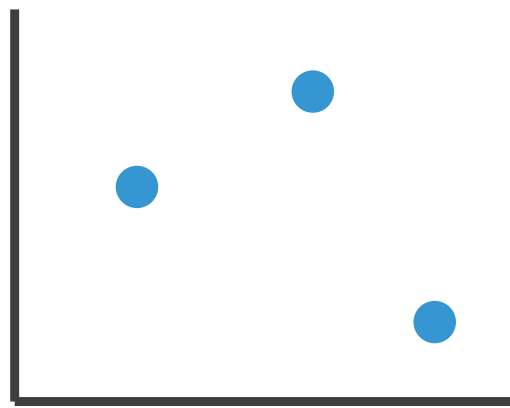
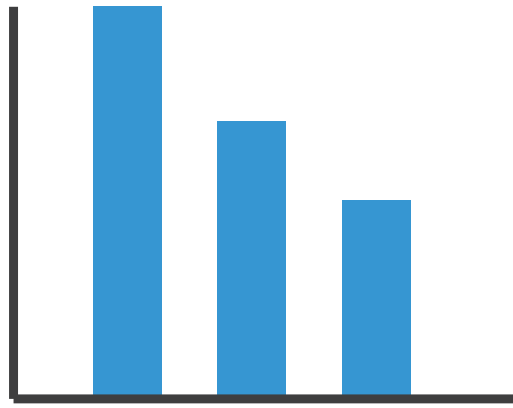
- How can you visually represent these two numbers?
 - Solo: quickly sketch 3 ideas
 - Pair: compare with your neighbor
 - Q: how many matched?
 - Together: sketch 2 more different ones
- Keep pix for Foundations 2
 - (snap a picture so each of you has it)
- Many possibilities!

<https://visual.ly/blog/45-ways-to-communicate-two-quantities/>

Marks and Channels

Visual encoding

- how to systematically analyze idiom structure?



- marks & channels
 - marks: represent items or links
 - channels: change appearance of marks based on attributes

Marks for items

- basic geometric elements

➞ Points



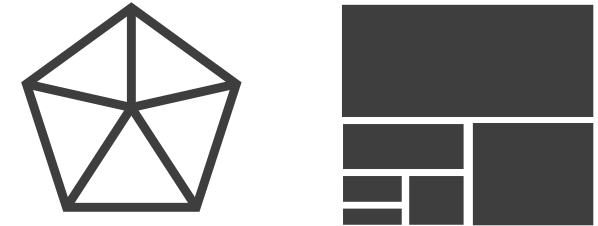
0D

➞ Lines



1D

➞ Areas

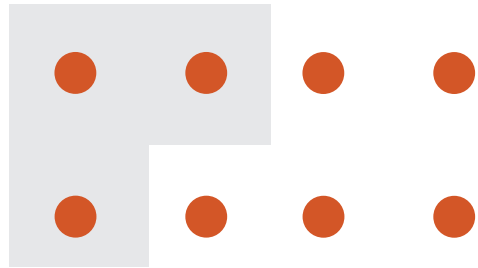


2D

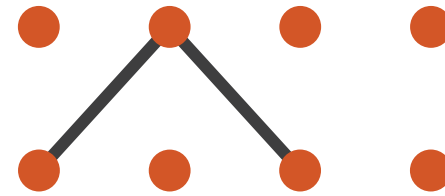
- 3D mark: volume, rarely used

Marks for links

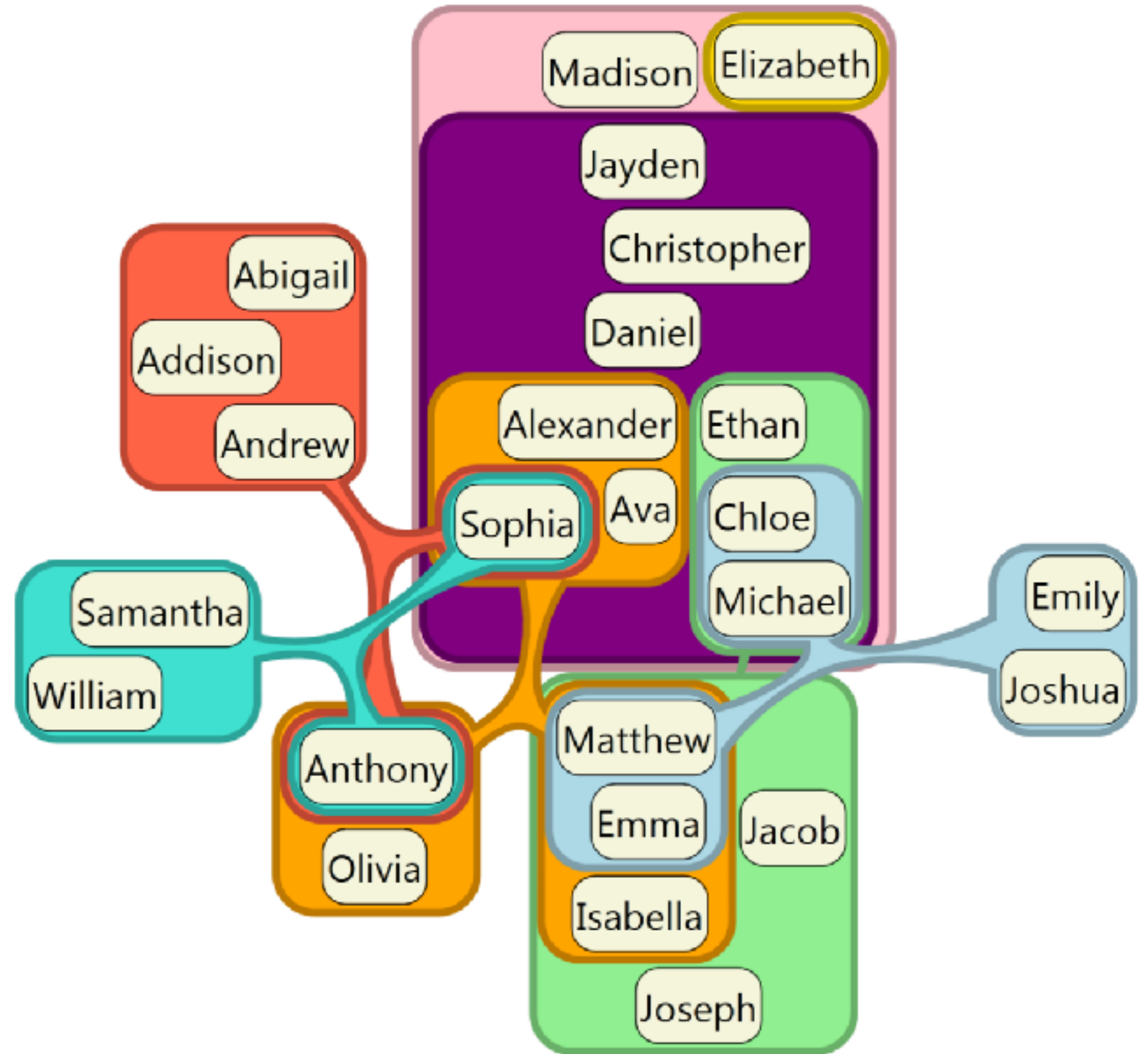
➔ Containment



➔ Connection



Containment can be nested



[Untangling Euler Diagrams, Riche and Dwyer, 2010]

Channels

- control appearance of marks

- proportional to or based on attributes

- many names

- **visual channels**

- visual variables

- retinal channels

- visual dimensions

- ...

➞ Position

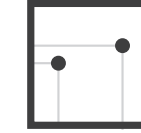
➞ Horizontal



➞ Vertical



➞ Both



➞ Shape



➞ Size

➞ Length



➞ Area



➞ Color



➞ Tilt

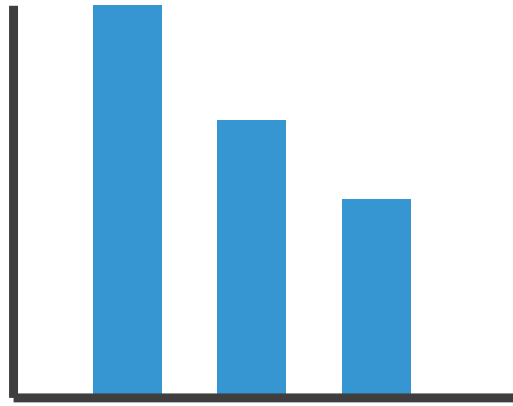


➞ Volume



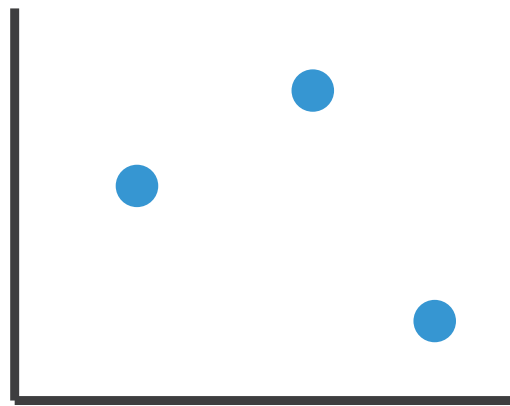
Visual encoding

- analyze idiom structure
 - as combination of marks and channels



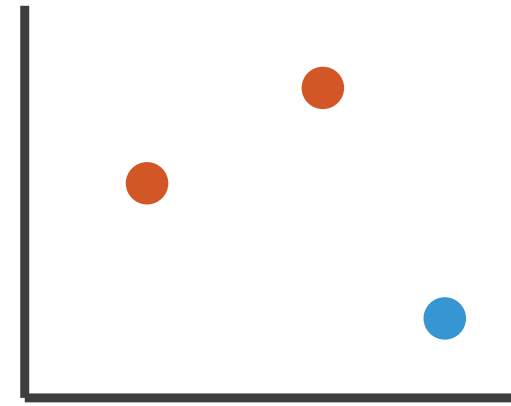
1:
vertical position

mark: line



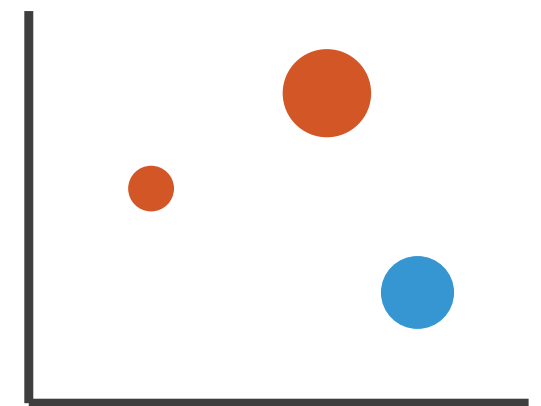
2:
vertical position
horizontal position

mark: point



3:
vertical position
horizontal position
color hue

mark: point

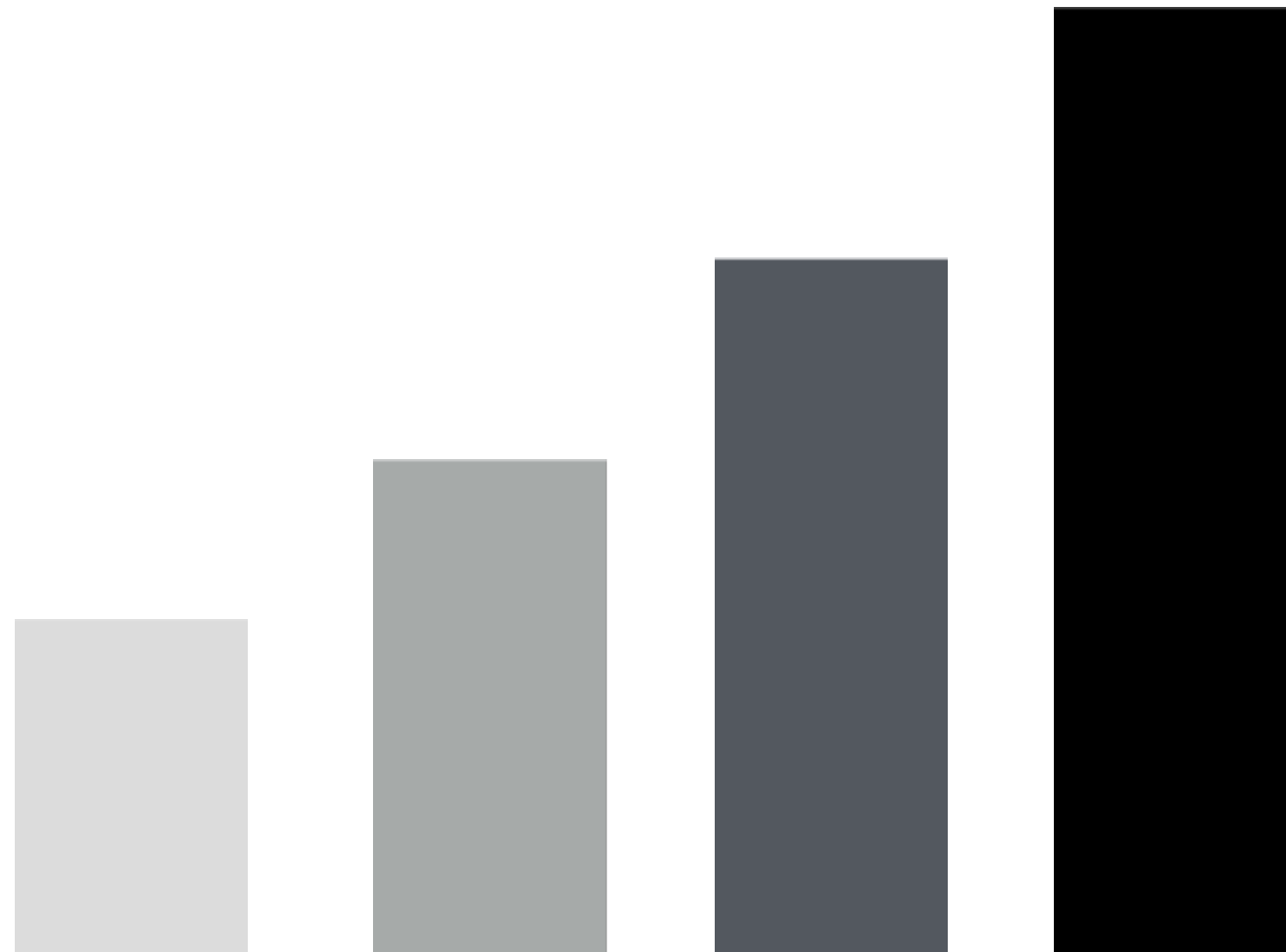


4:
vertical position
horizontal position
color hue
size (area)

mark: point

Redundant encoding

- multiple channels
 - sends stronger message
 - but uses up channels



Length, Position, and Value

What is wrong with this picture?

- should use channel proportional to data!



<https://twitter.com/ChaseThomason/status/1118478036507164672?s=19>

When to use which channel?

expressiveness

match channel type to data type

effectiveness

some channels are better than others

Channels

Position on common scale



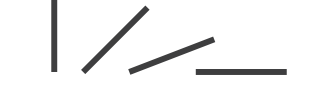
Position on unaligned scale



Length (1D size)



Tilt/angle



Area (2D size)



Depth (3D position)



Color luminance



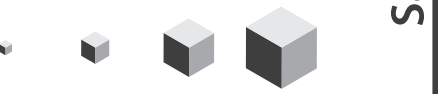
Color saturation



Curvature



Volume (3D size)



Spatial region



Color hue



Motion



Shape



Channels: Matching Types

➔ **Magnitude** Channels: **Ordered** Attributes

Position on common scale 

Position on unaligned scale 

Length (1D size) 

Tilt/angle 

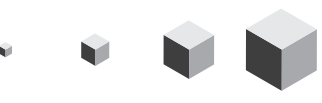
Area (2D size) 

Depth (3D position) 

Color luminance 

Color saturation 

Curvature 

Volume (3D size) 

Same

Same

➔ **Identity** Channels: **Categorical** Attributes

Spatial region 

Color hue 

Motion 

Shape 

- **expressiveness principle**
 - match channel and data characteristics
 - magnitude for ordered
 - how much? which rank?
 - identity for categorical
 - what?

Channels: Rankings

➔ **Magnitude** Channels: **Ordered** Attributes



➔ **Identity** Channels: **Categorical** Attributes



- **expressiveness principle**
 - match channel and data characteristics
- **effectiveness principle**
 - encode most important attributes with highest ranked channels

Channels: Expressiveness types and effectiveness rankings

➔ **Magnitude Channels: Ordered Attributes**

Position on common scale



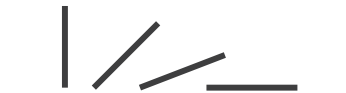
Position on unaligned scale



Length (1D size)



Tilt/angle



Area (2D size)



Depth (3D position)



Color luminance



Color saturation



Curvature



Volume (3D size)



Same

Same

➔ **Identity Channels: Categorical Attributes**

Spatial region



Color hue



Motion



Shape



Best

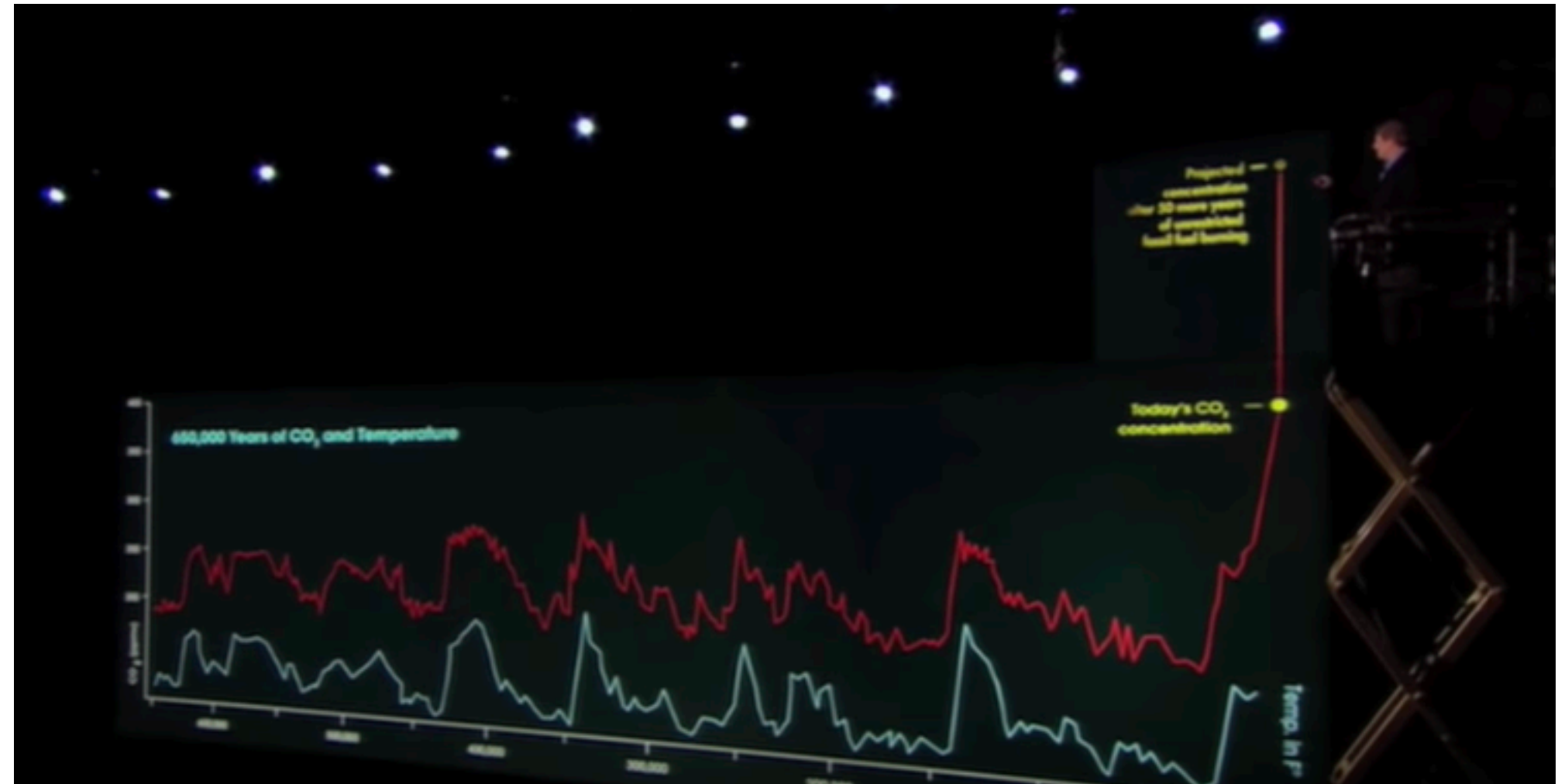
Effectiveness

Least

- **expressiveness principle**
 - match channel and data characteristics
- **effectiveness principle**
 - encode most important attributes with highest ranked channels
 - spatial position ranks high for both

Quiz: Name those channels

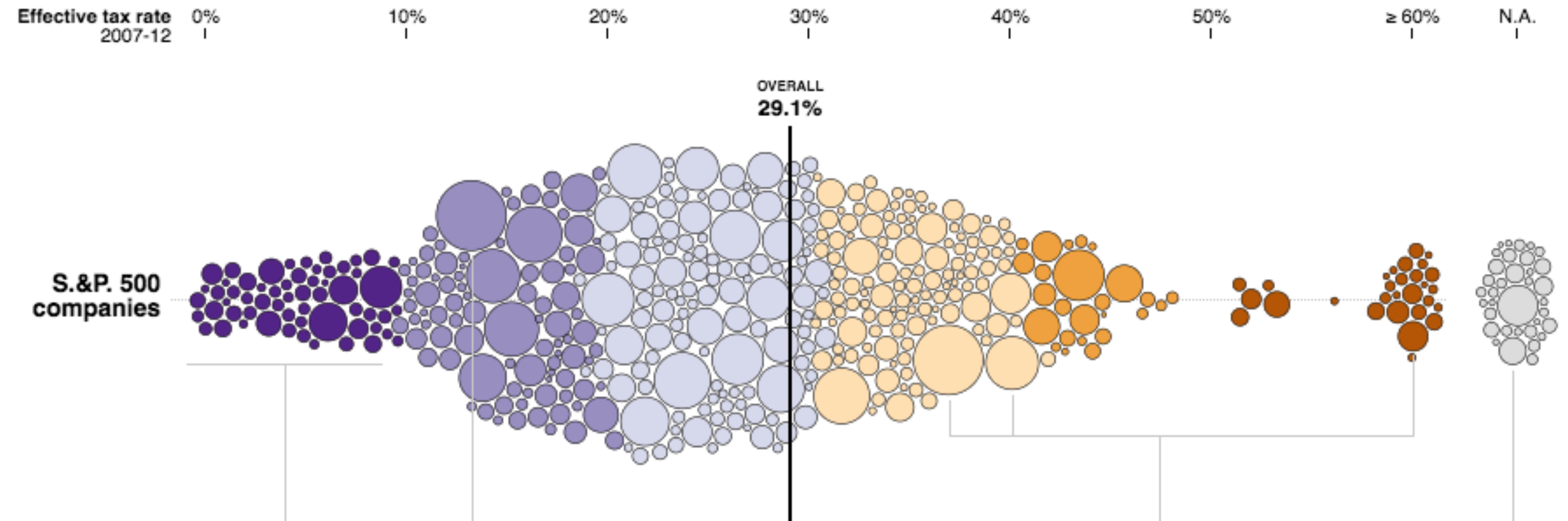
- A: Inconvenient Truth



<https://www.youtube.com/watch?v=9tkDK2mZlOo>

Quiz: Name those channels

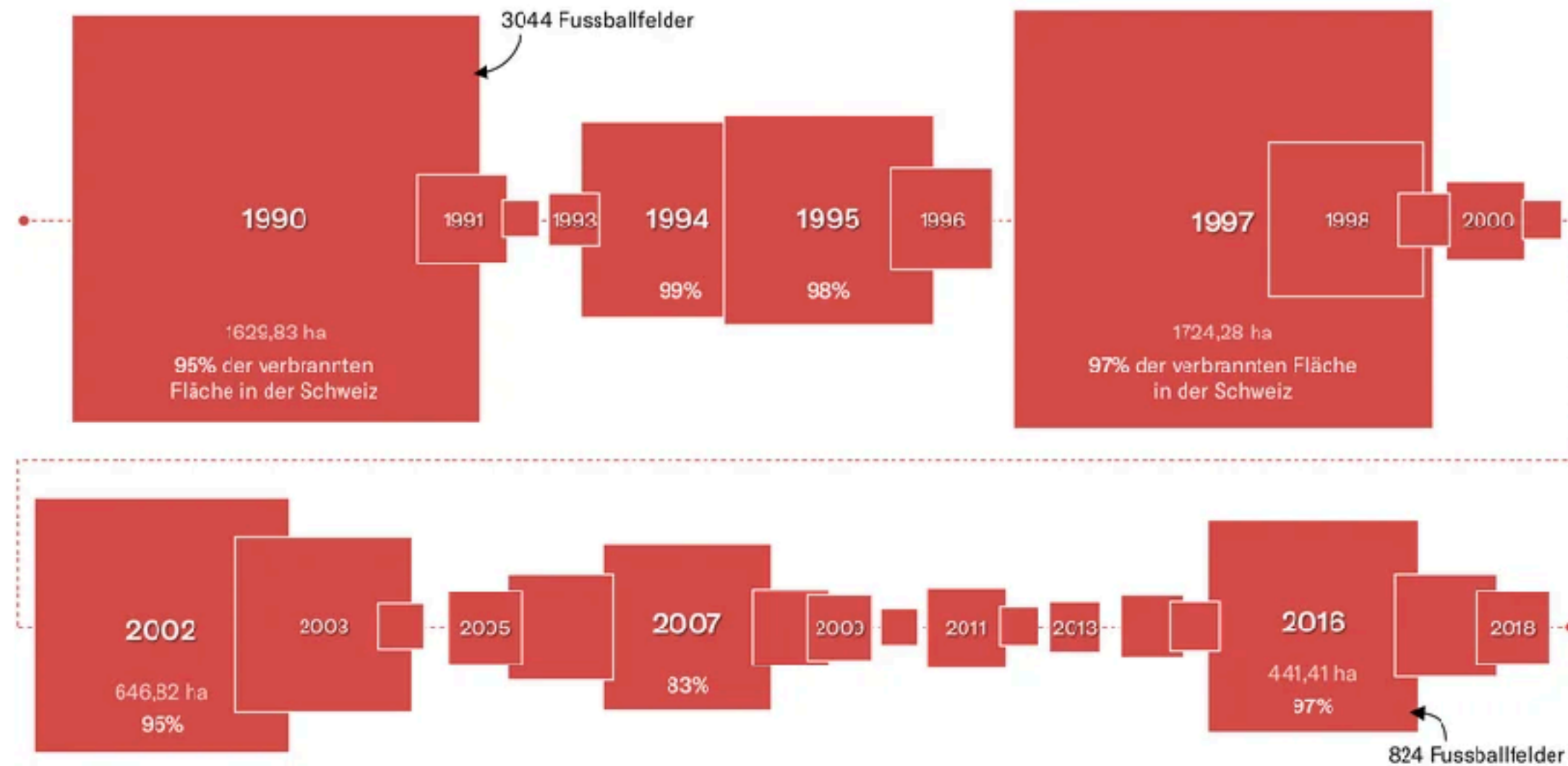
- B:Tax Rates



Quiz: Name those channels

- C:Alpen Forest Fires

Burned area in hectares on the southern side of the Alps



Source: Swissfire forest fire database

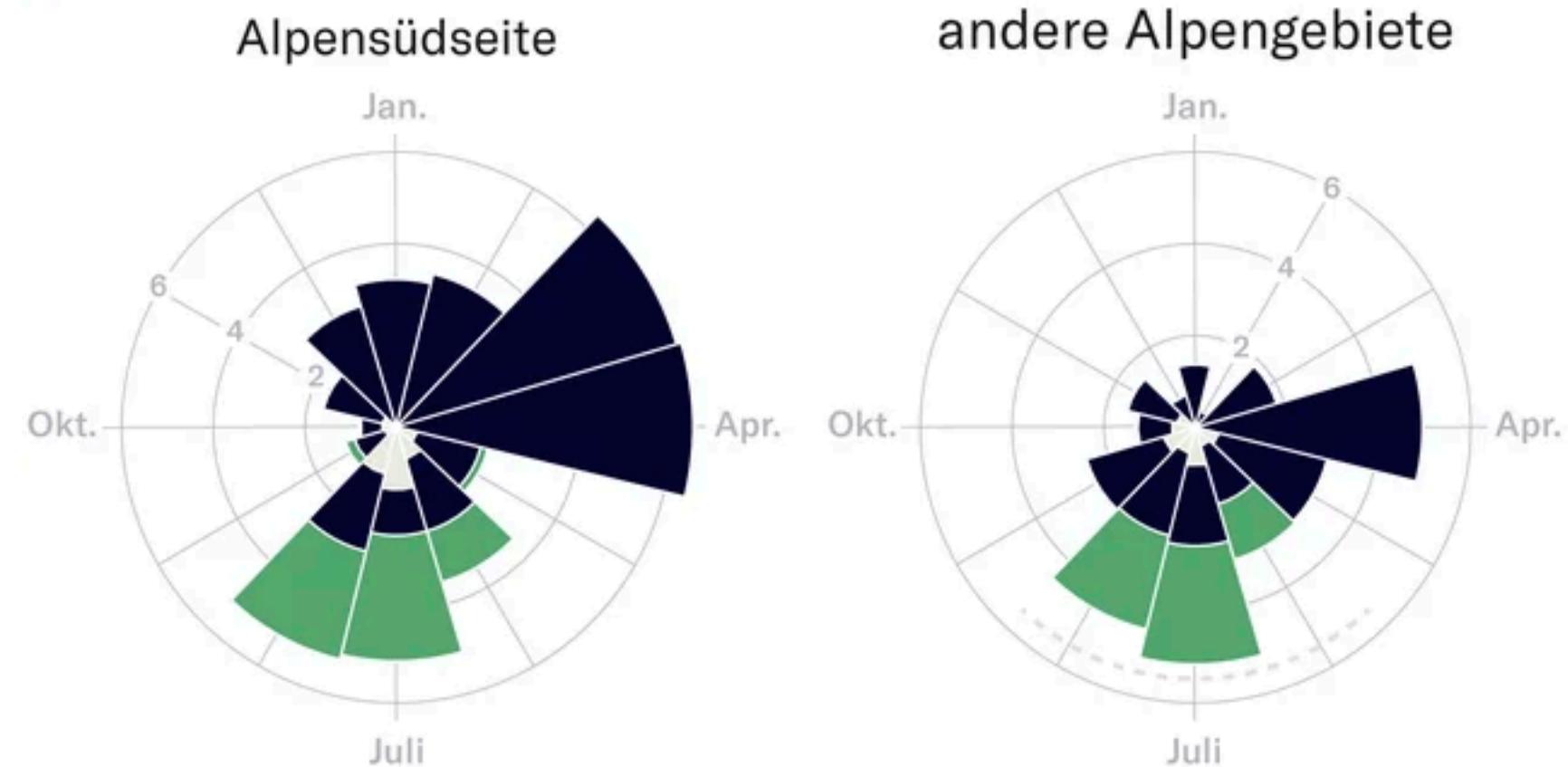
NZZ / awi.

Quiz: Name those channels

- D: More Alpen Forest Fires

Monthly distribution of forest fires in the Alpine regions caused by. , ,

● den Menschen ● Blitzschläge ● unbekannt

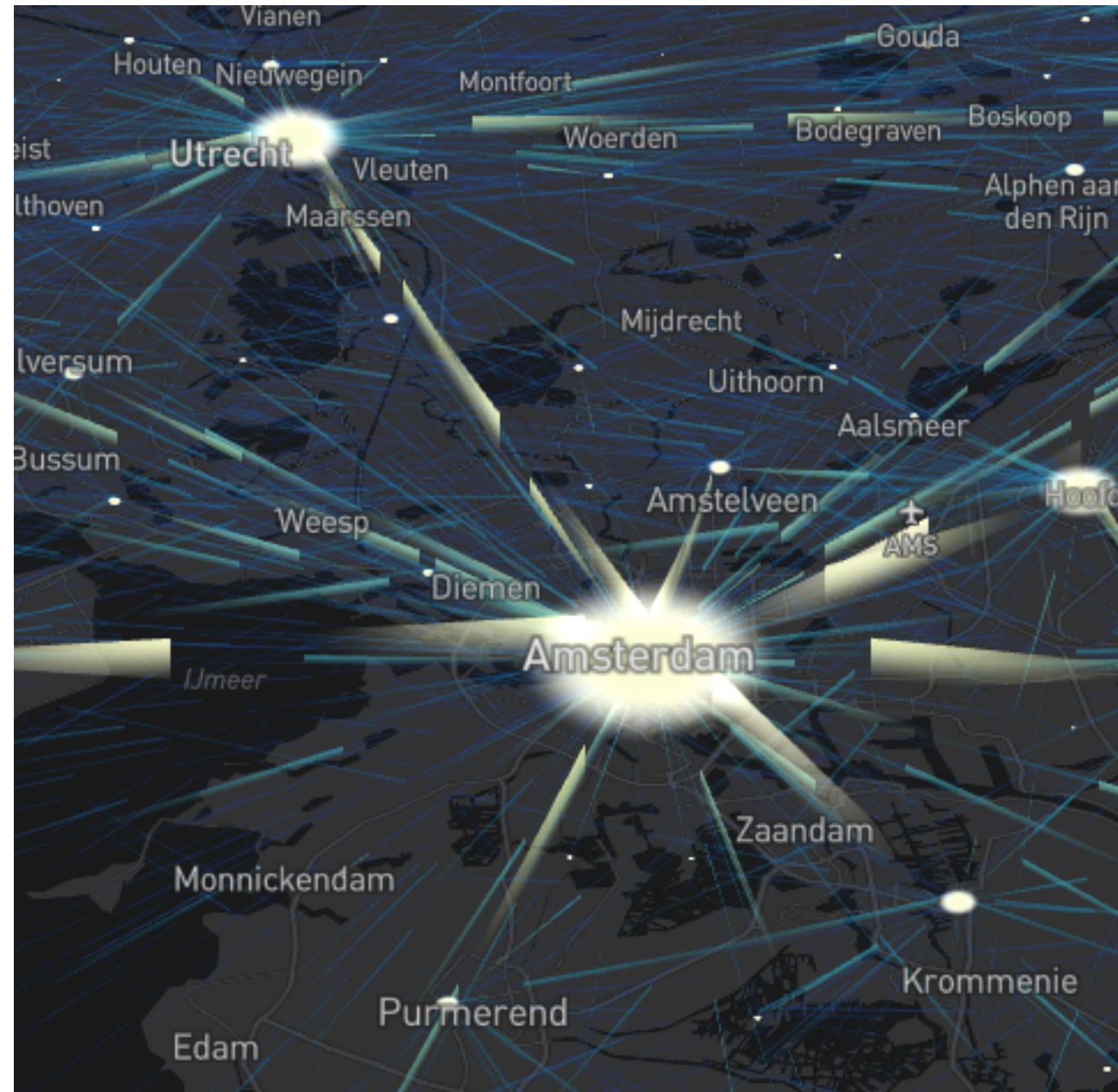


Average numbers in the period 2000-2018
Source: Swissfire forest fire database

NZZ / awi.

Quiz: Name those channels

- E: Netherlands Commuters



<https://observablehq.com/@ilyabo/animated-flow-map-of-commuters-in-the-netherlands-in-2016>

Reminder: Marks and channels

- marks

- basic geometric elements

➞ Points



➞ Lines



➞ Areas



- channels

- control appearance of marks

➞ Position

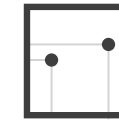
➞ Horizontal



➞ Vertical



➞ Both



➞ Color



➞ Shape



➞ Tilt



➞ Size

➞ Length



➞ Area



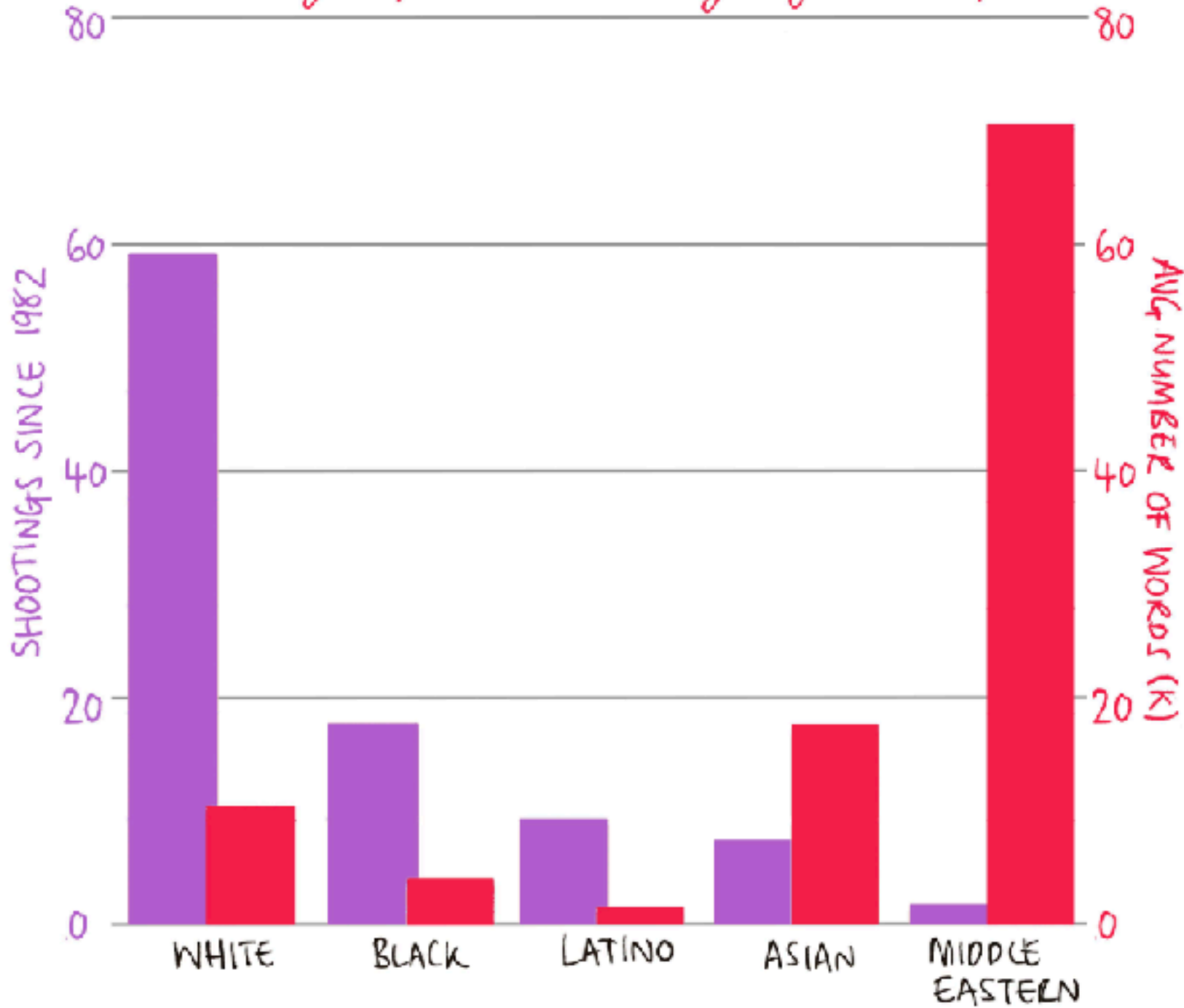
➞ Volume



Quiz: Name that mark

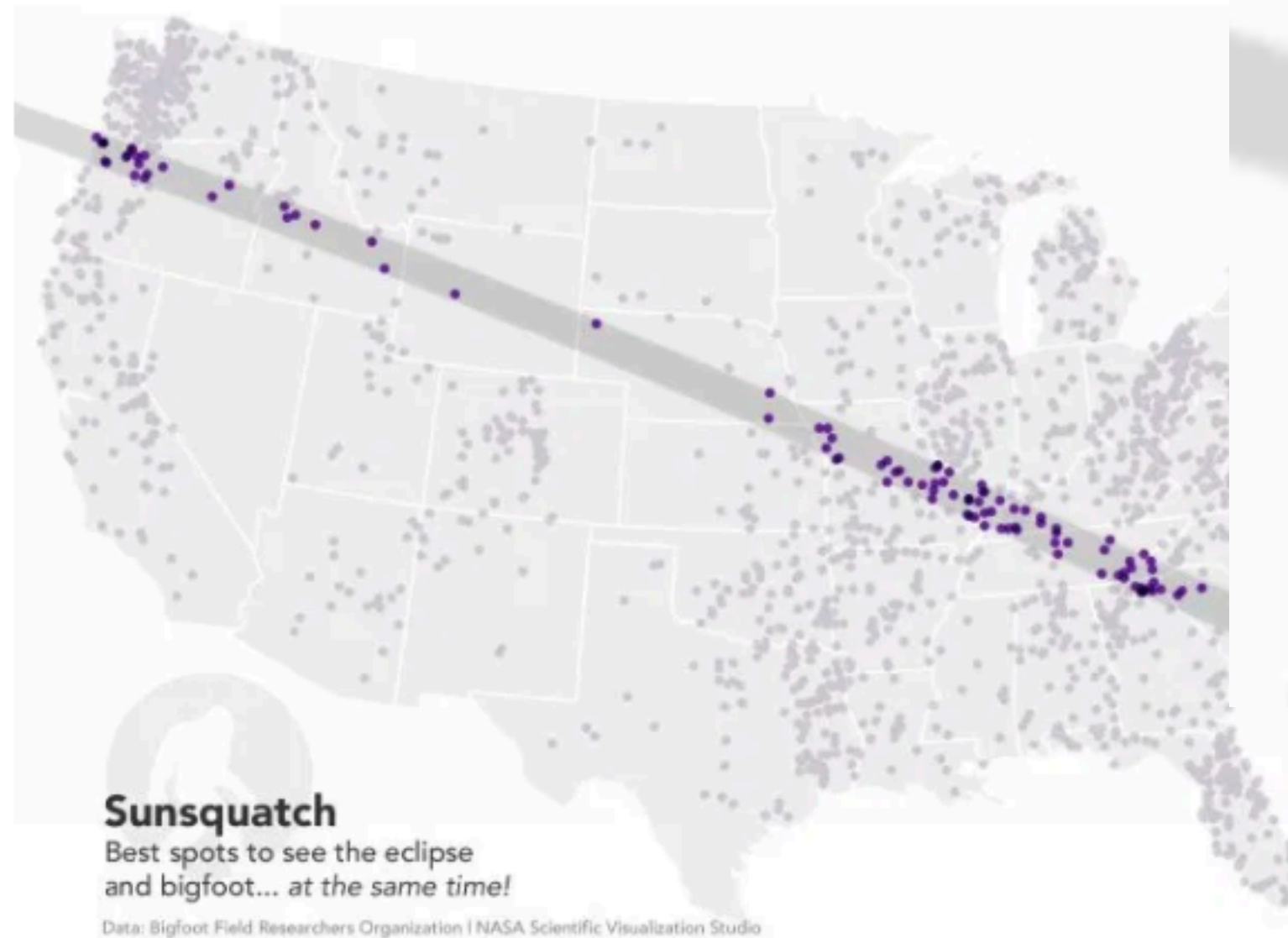
- A: Shooting Media Coverage

Mass Shootings By Race Of Shooter
NYTimes Coverage Of Mass Shootings By Race Of Shooter



Quiz: Name that mark

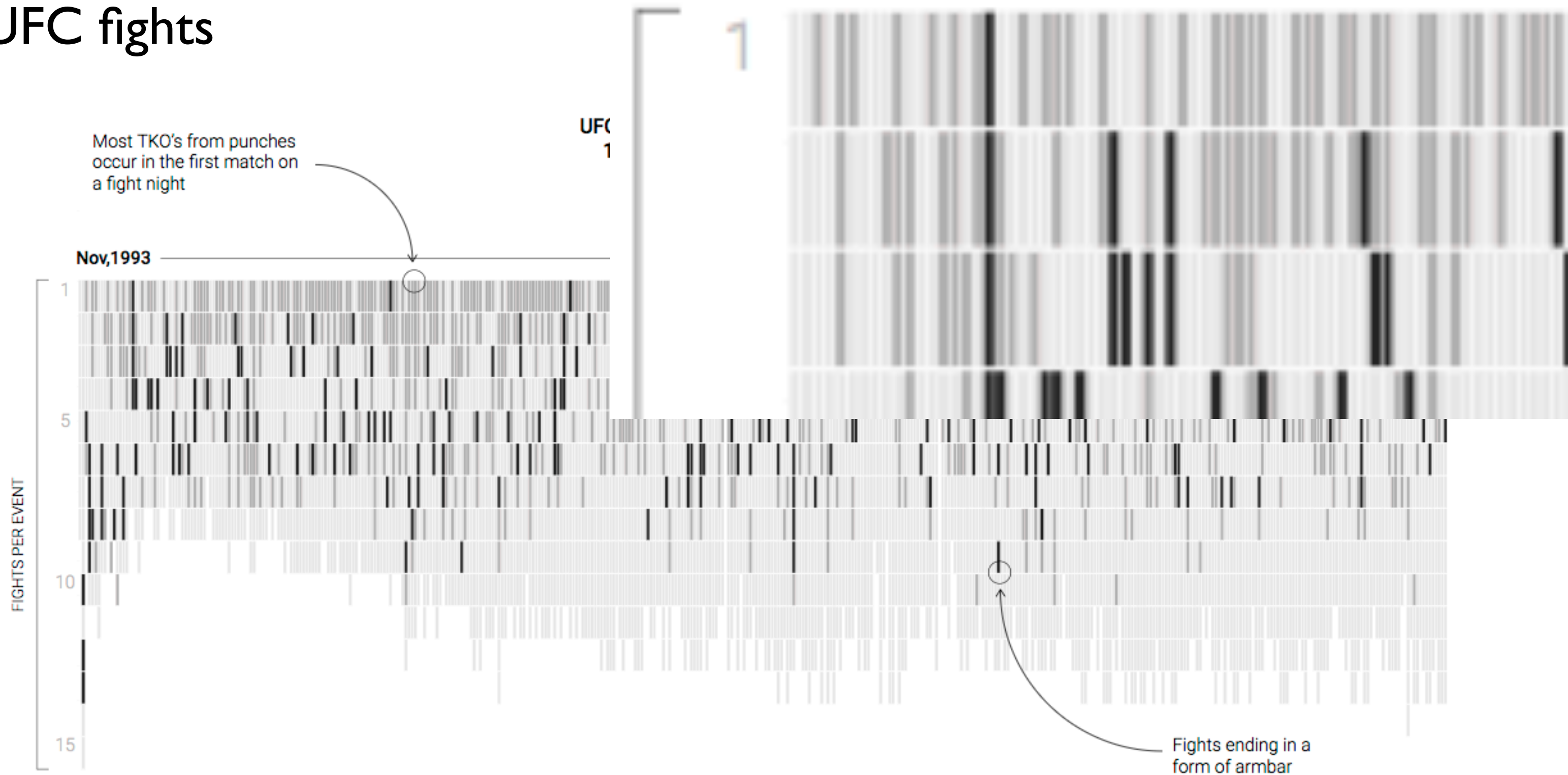
- B: Sunsquatch



<https://flowingdata.com/2017/08/20/sunsquatch-the-only-eclipse-map-you-need/>

Quiz: Name that mark

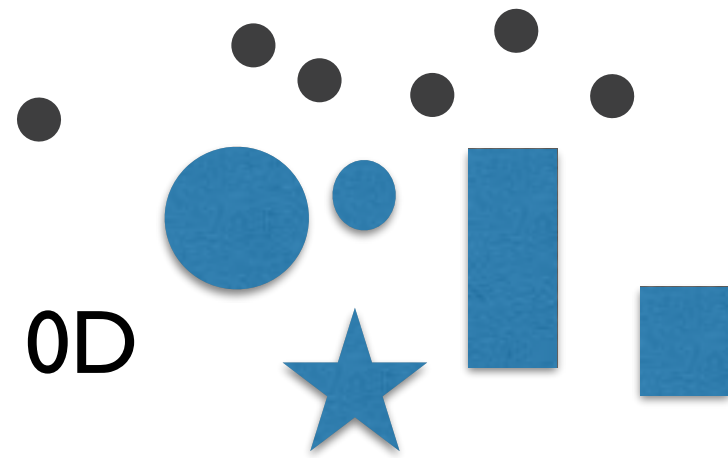
- C: UFC fights



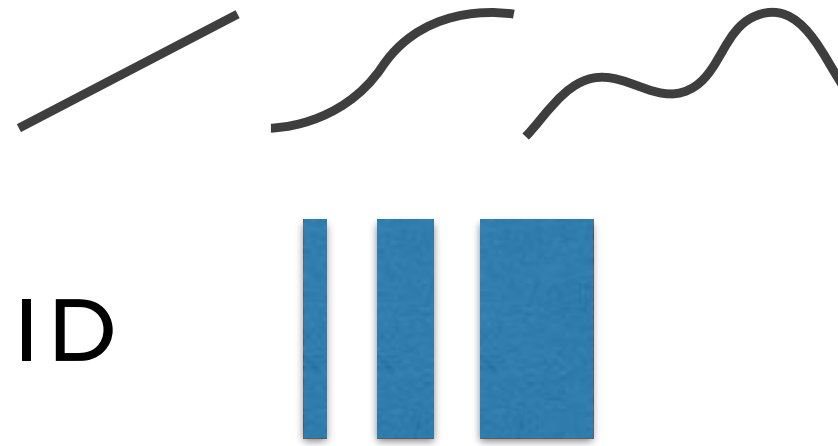
Marks: Constrained vs encodable

- math view: geometric primitives have dimensions

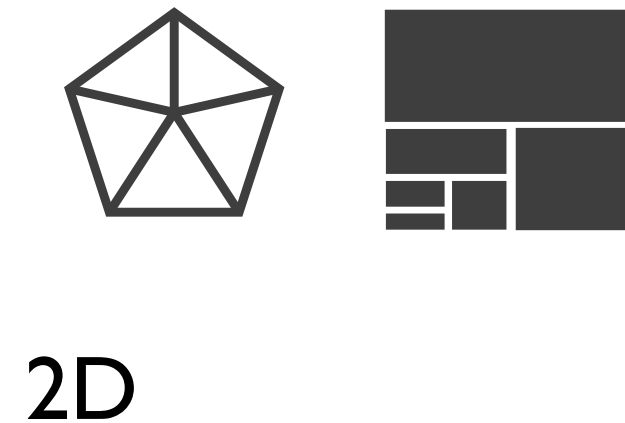
➞ Points



➞ Lines



➞ Areas



- constraint view: mark type constrains what else can be encoded
 - points: 0 constraints on size, can encode more attributes w/ size & shape
 - lines: 1 constraint on size (length), can still size code other way (width)
 - areas: 2 constraints on size (length/width), cannot size code or shape code
- quick check: can you size-code another attribute, or is size/shape in use?

Analyzing marks

- what type of mark?
 - line?
 - no, not length coded
 - point mark with rectangular shape?
 - yes!
 - area?
 - no, area/shape does not convey meaning

Nov, 1993



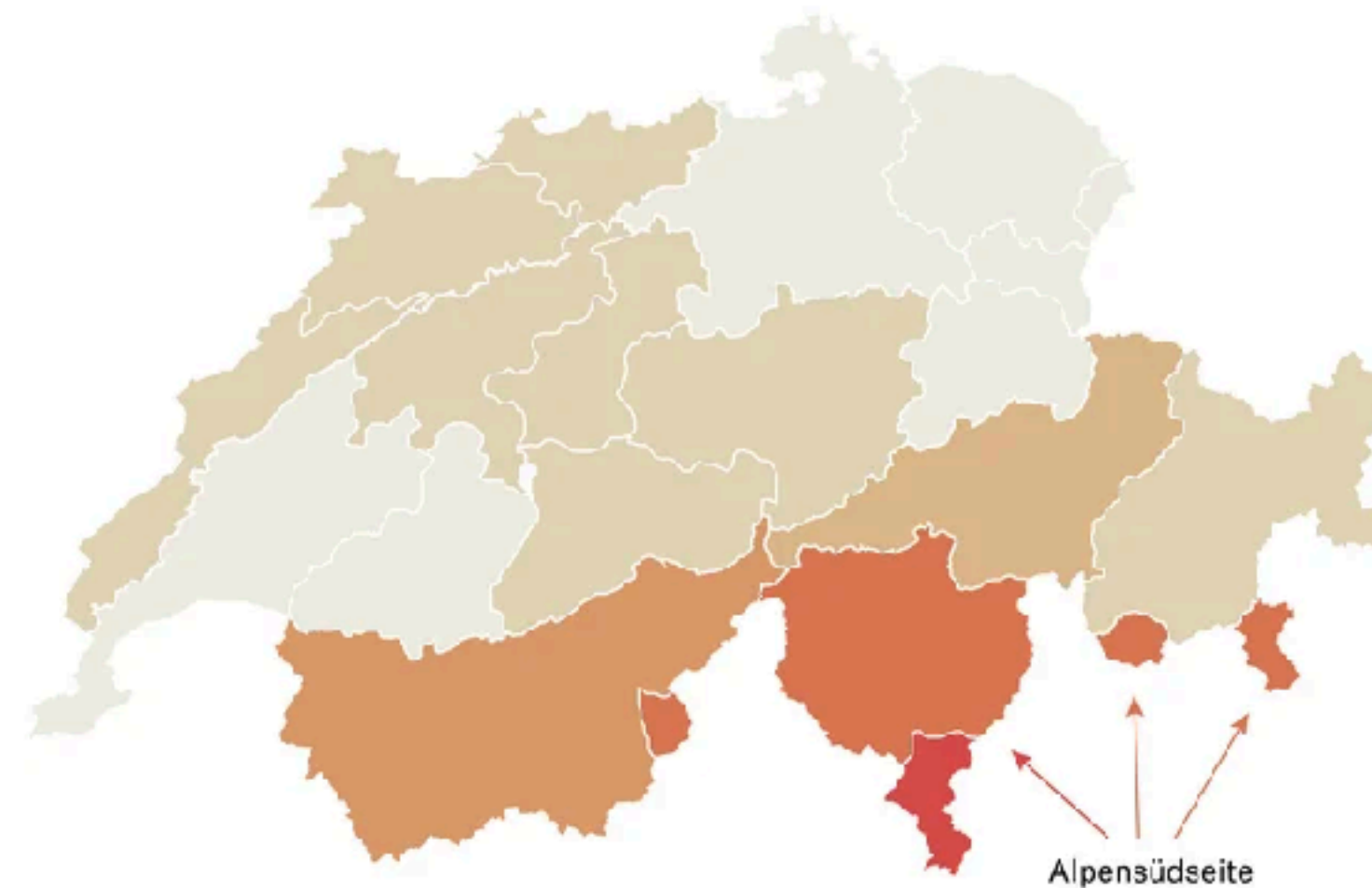
Quiz: Name that mark

- D: Yet More Alpen Forest Fires

Most forest fires in Switzerland occur on the southern side of the Alps. , ,

Annual number of forest fires between 1990 and 2014

< 1 Waldbrand 1-2 2-3 3-5 5-15 > 15



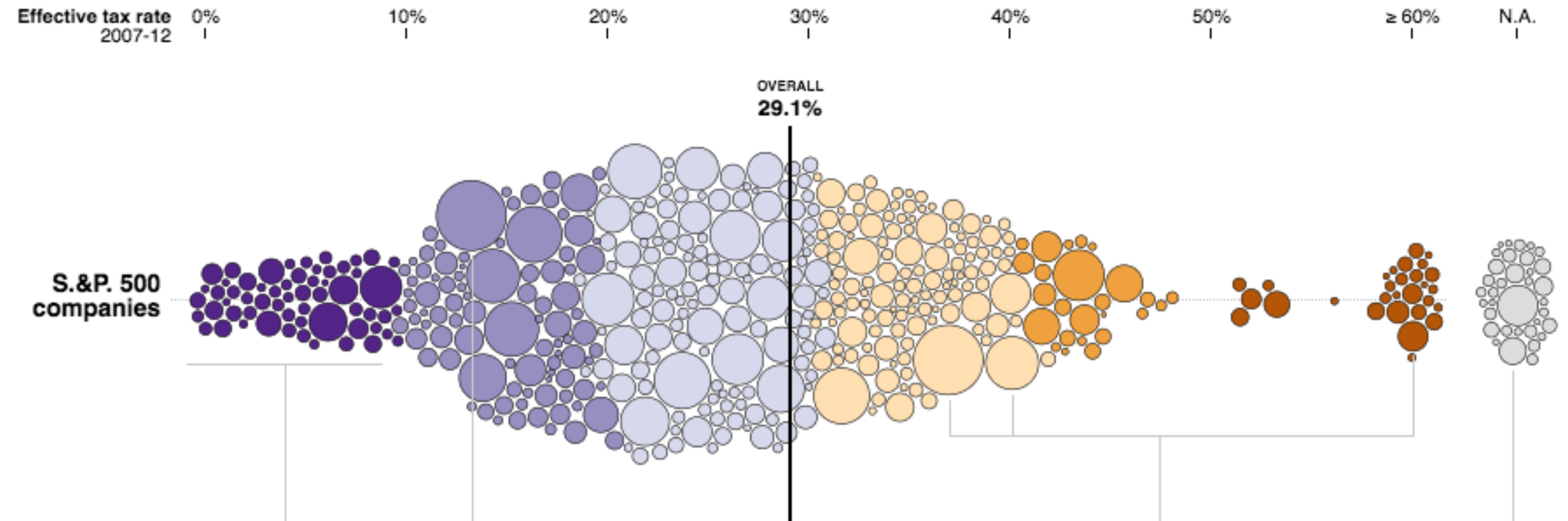
Source: Climate Change Forest, Pluess et al., 2016

NZZ / awi.

<https://www.nzz.ch/wissenschaft/waldbraende-erklaert-in-der-schweiz-und-in-europa-ld.1483688>

Quiz: Name that mark

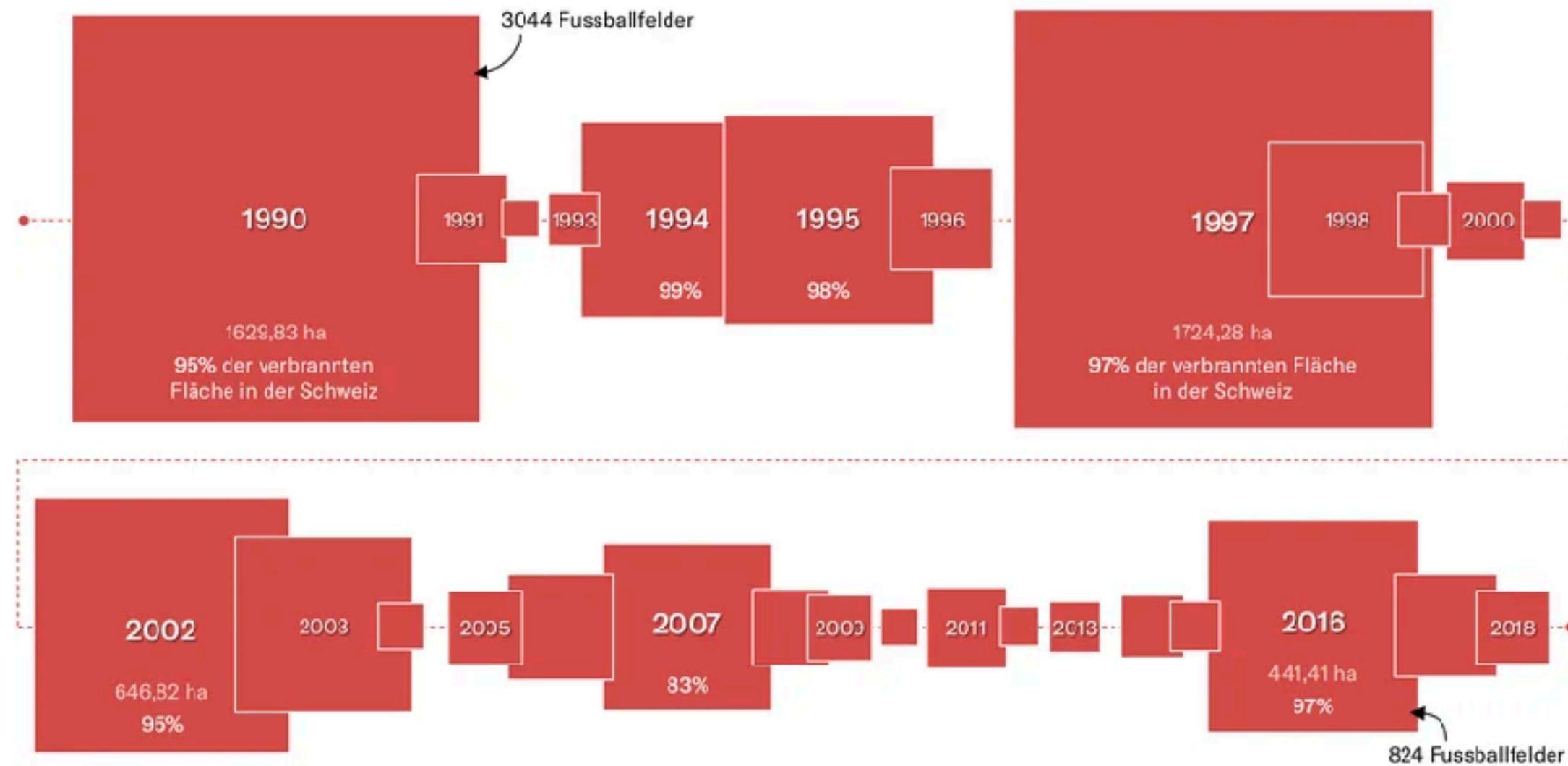
- E:Tax Rates



Quiz: Name that mark

- F:Alpen Forest Fires

Burned area in hectares on the southern side of the Alps



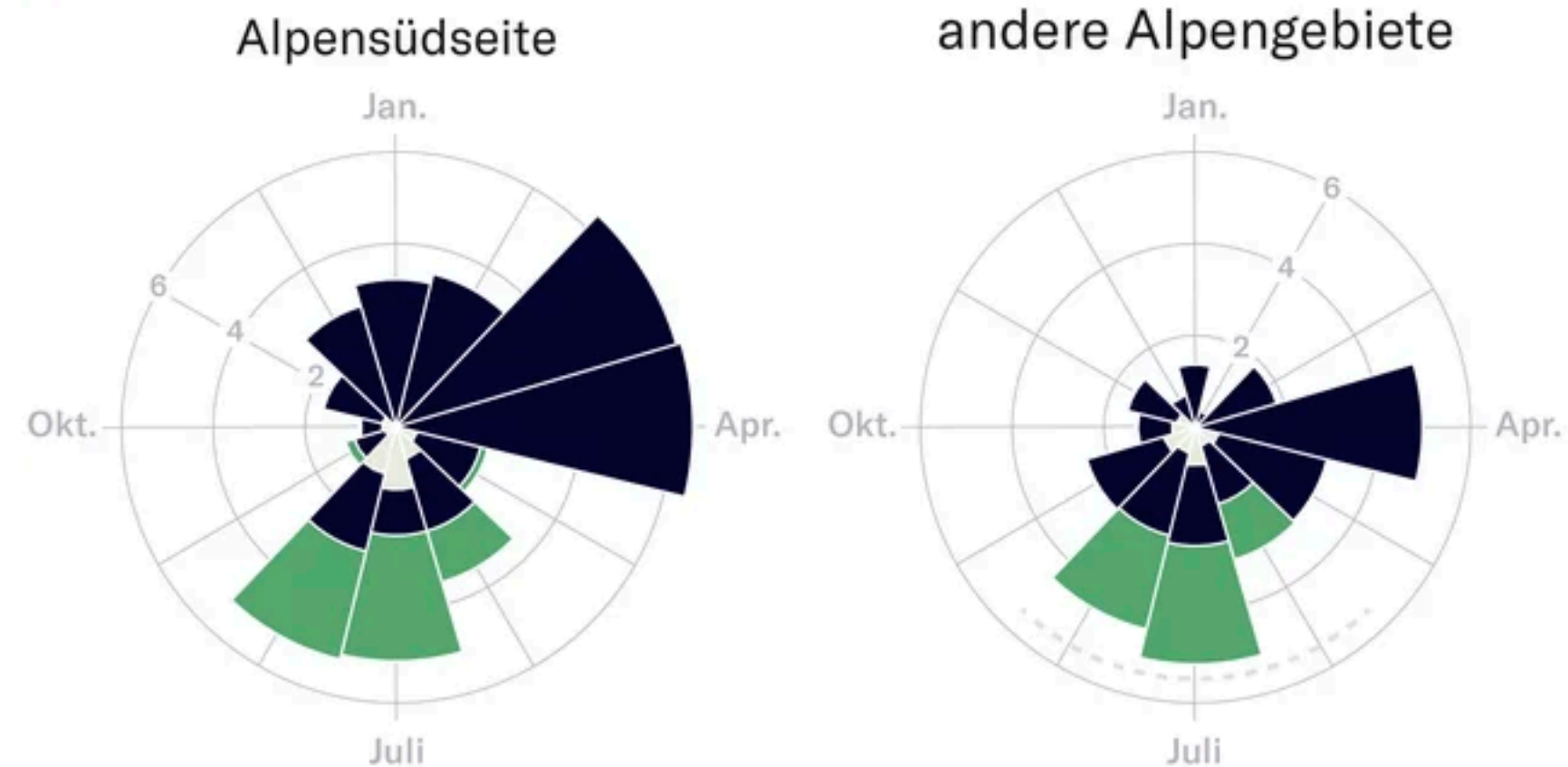
Source: Swissfire forest fire database

NZZ / awi.

- G: More Alpen Forest Fires

Monthly distribution of forest fires in the Alpine regions caused by. , ,

● den Menschen ● Blitzschläge ● unbekannt



Average numbers in the period 2000-2018
Source: Swissfire forest fire database

NZZ / awi.

Scope of analysis

- simplifying assumptions: one mark per item, single view
- later on
 - multiple views
 - multiple marks in a region (glyph)
 - some items not represented by marks (aggregation and filtering)

Channel effectiveness

- accuracy: how precisely can we tell the difference between encoded items?
- discriminability: how many unique steps can we perceive?
- separability: is our ability to use this channel affected by another one?
- popout: can things jump out using this channel?

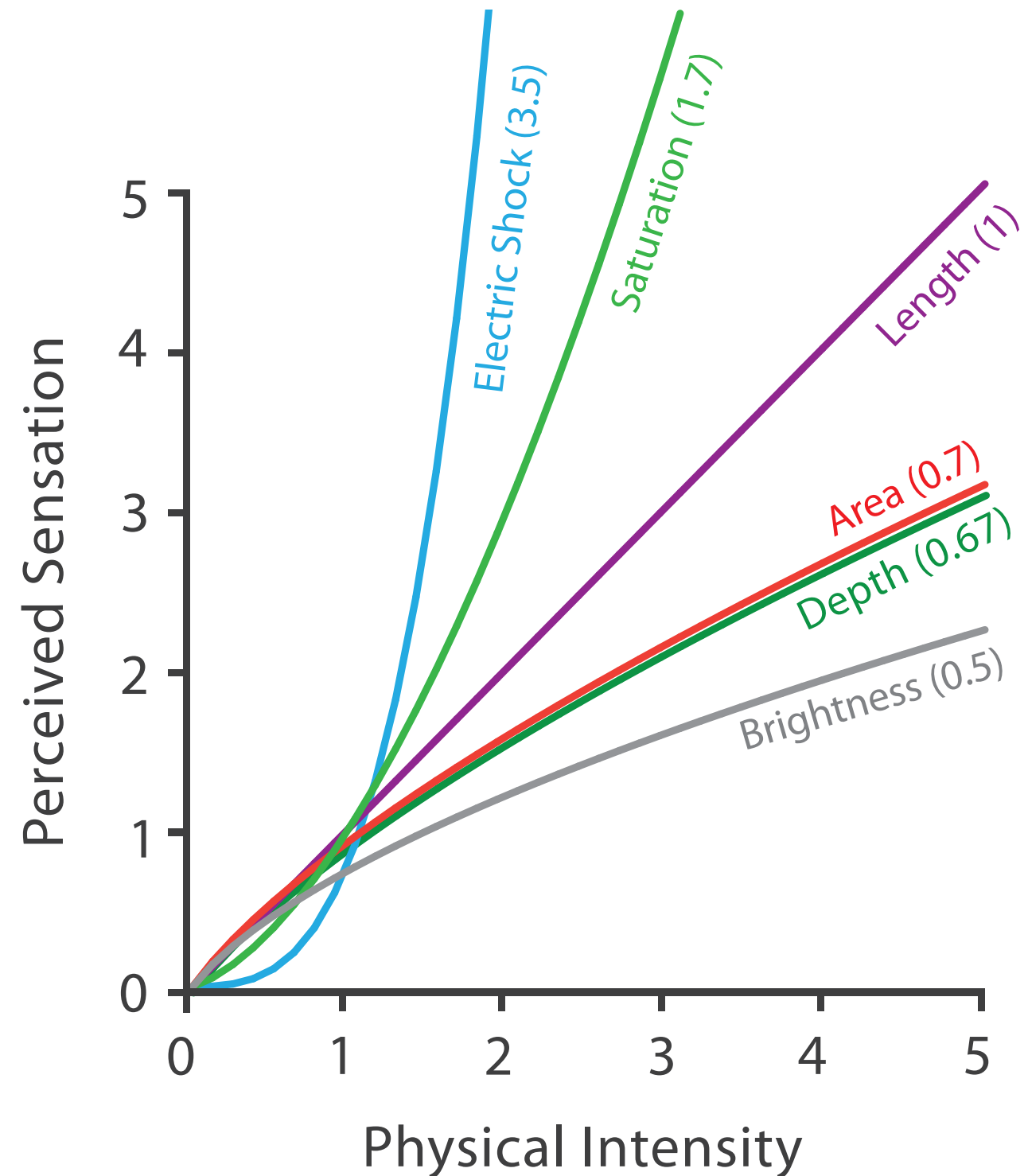
Accuracy: Fundamental theory

- length is accurate: linear
- others magnified or compressed
 - exponent characterizes

Steven's Psychophysical Power Law: $S = I^N$

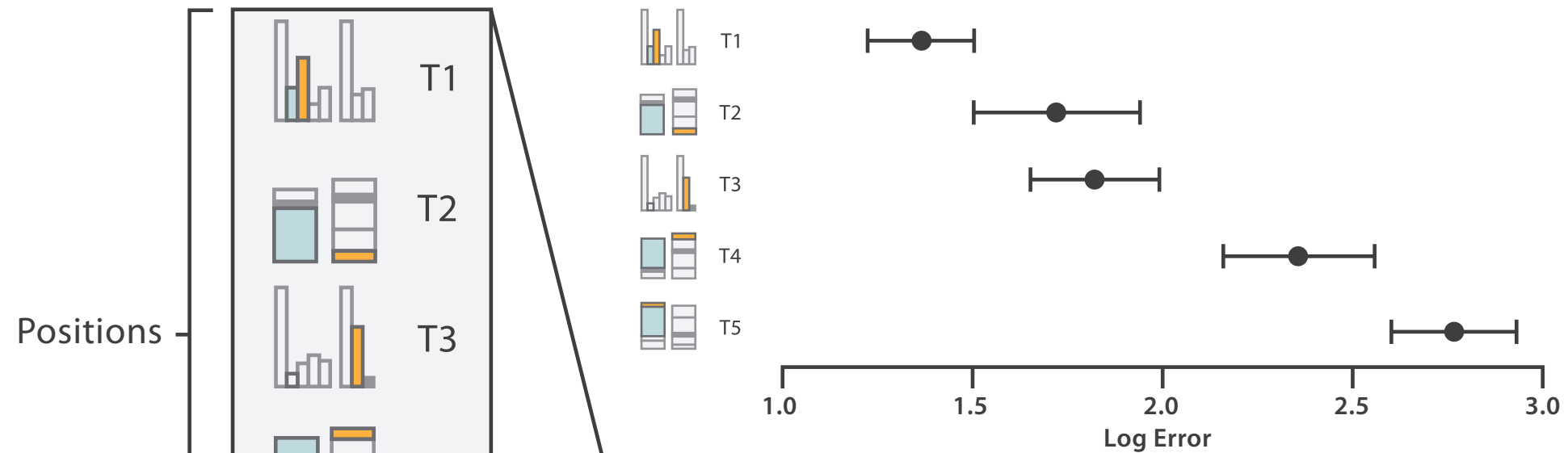
S = sensation

I = intensity

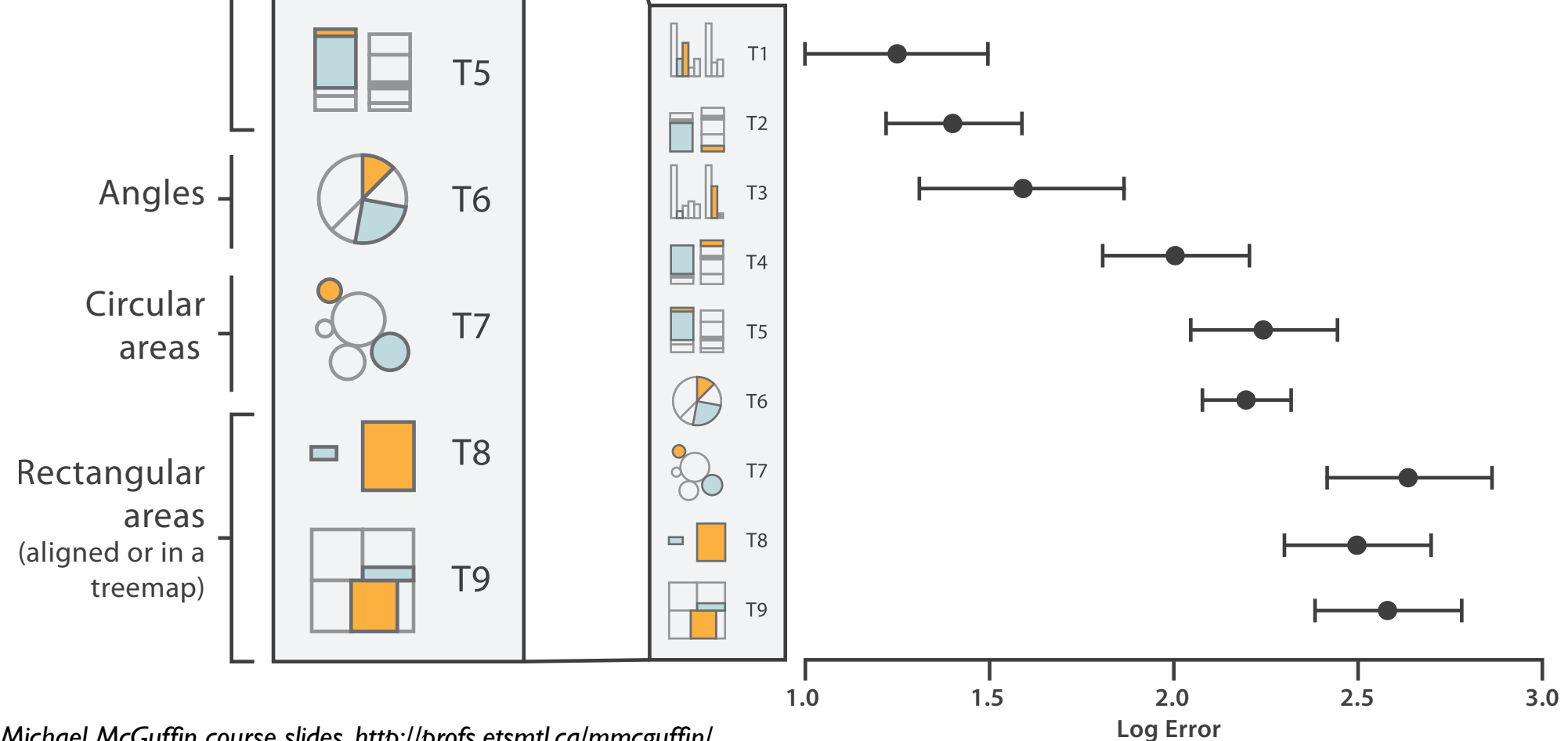


Accuracy: Vis experiments

Cleveland & McGill's Results



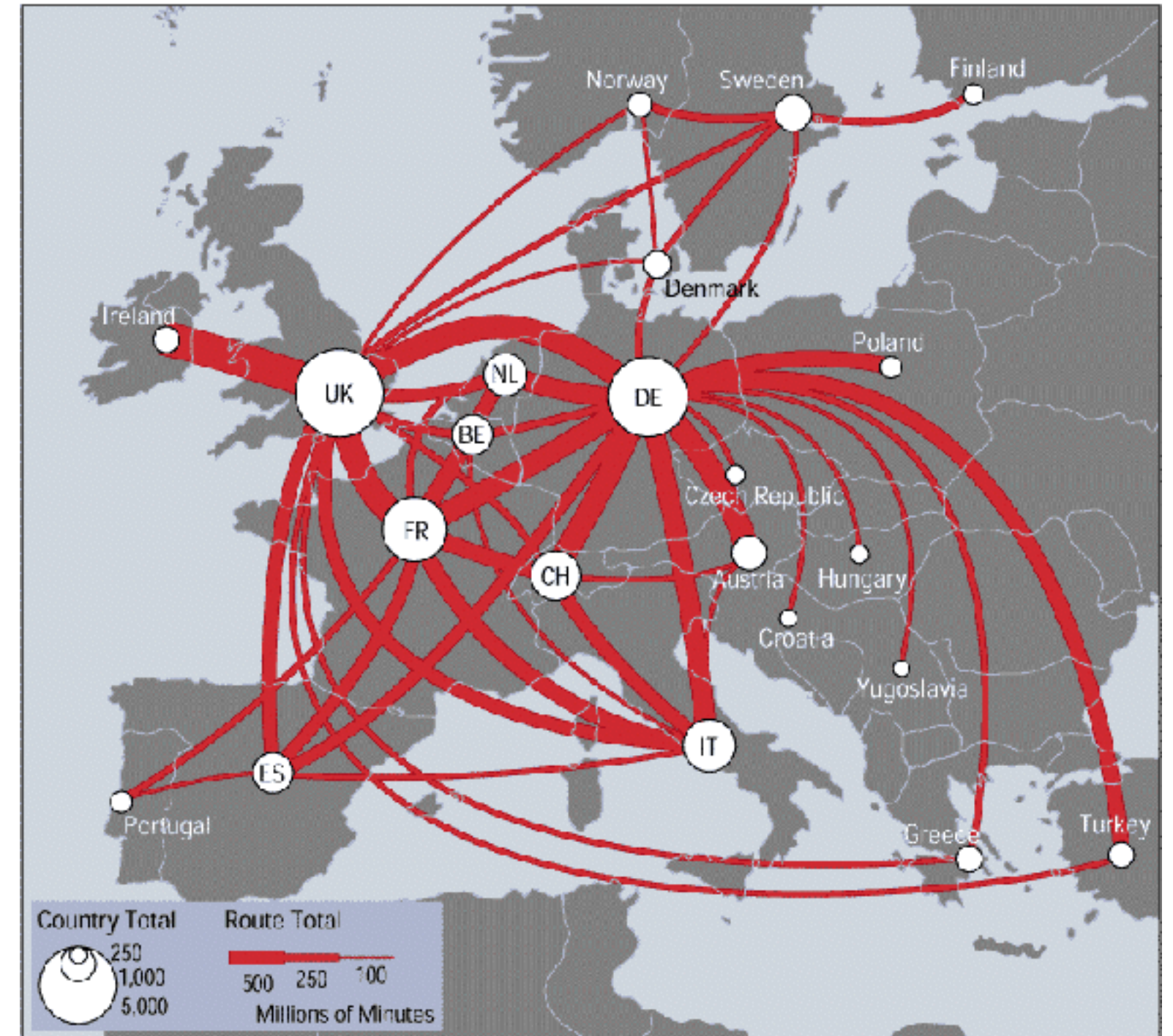
Crowdsourced Results



[Crowdsourcing Graphical Perception: Using Mechanical Turk to Assess Visualization Design. Heer and Bostock. Proc ACM Conf. Human Factors in Computing Systems (CHI) 2010, p. 203–212.]

Discriminability: How many usable steps?

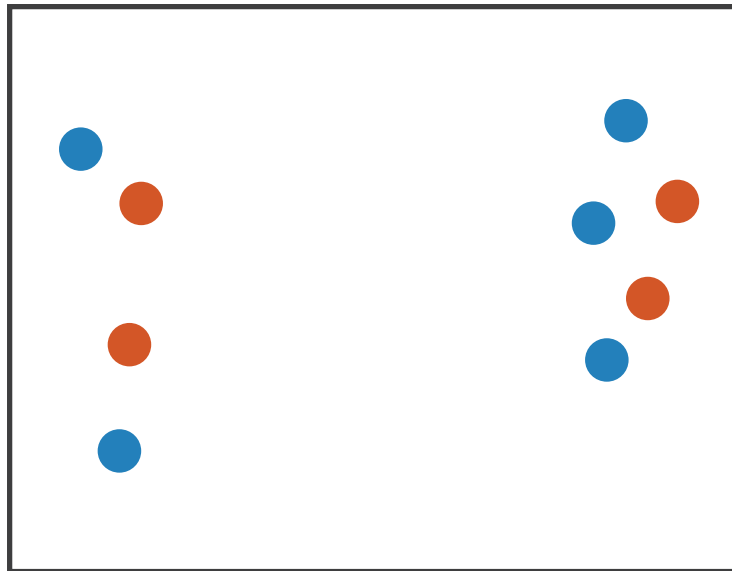
- must be sufficient for number of attribute levels to show
 - linewidth: few bins but salient



[mappa.mundi.net/maps/maps_014/telegeography.html]

Separability vs. Integrality

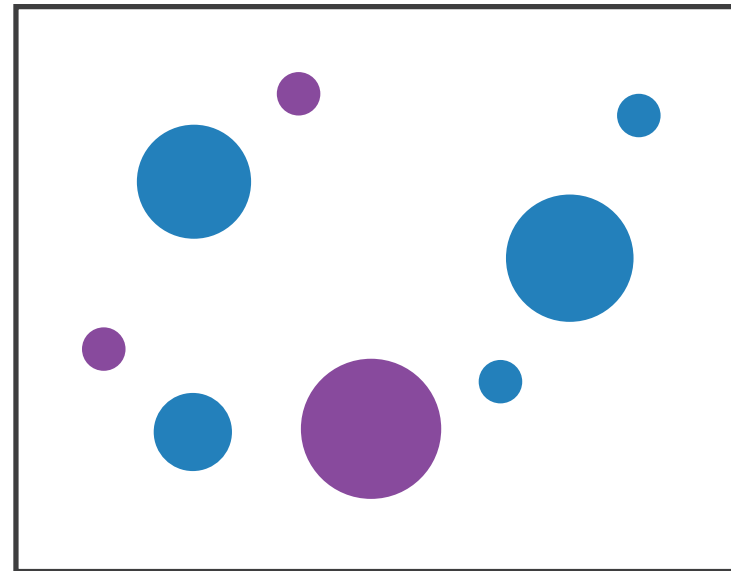
Position
+ Hue (Color)



Fully separable

2 groups each

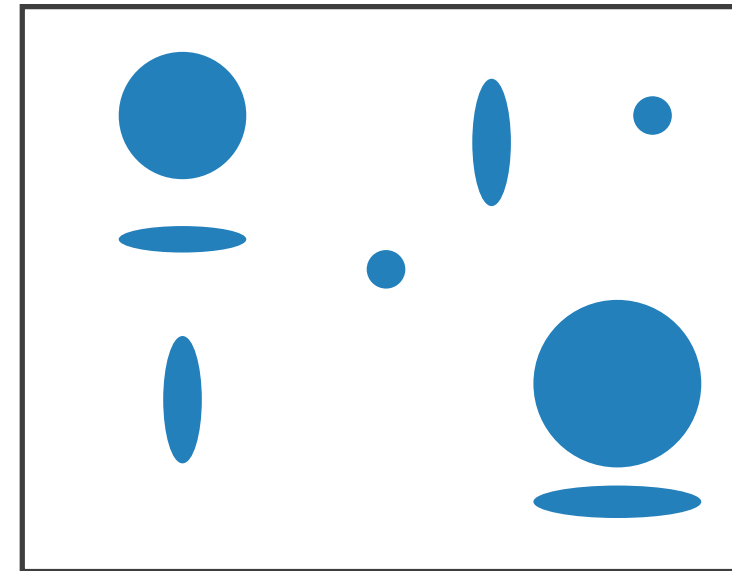
Size
+ Hue (Color)



Some interference

2 groups each

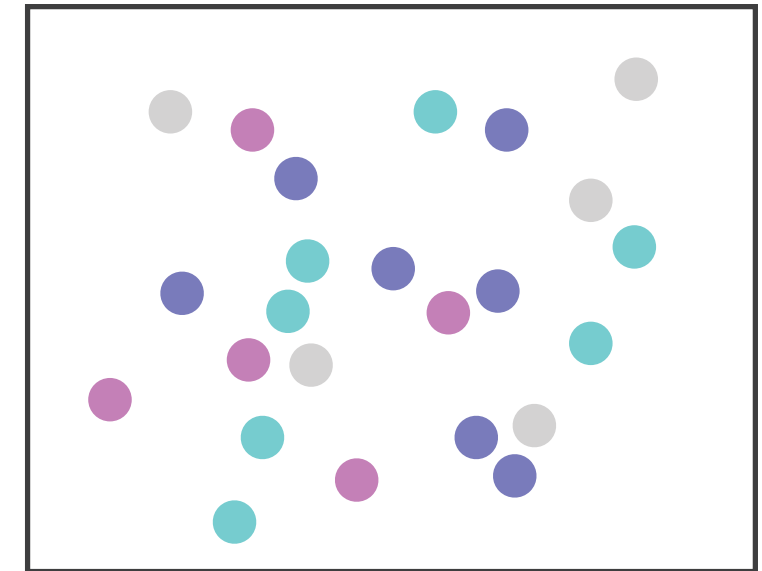
Width
+ Height



Some/significant
interference

3 groups total:
integral area

Red
+ Green

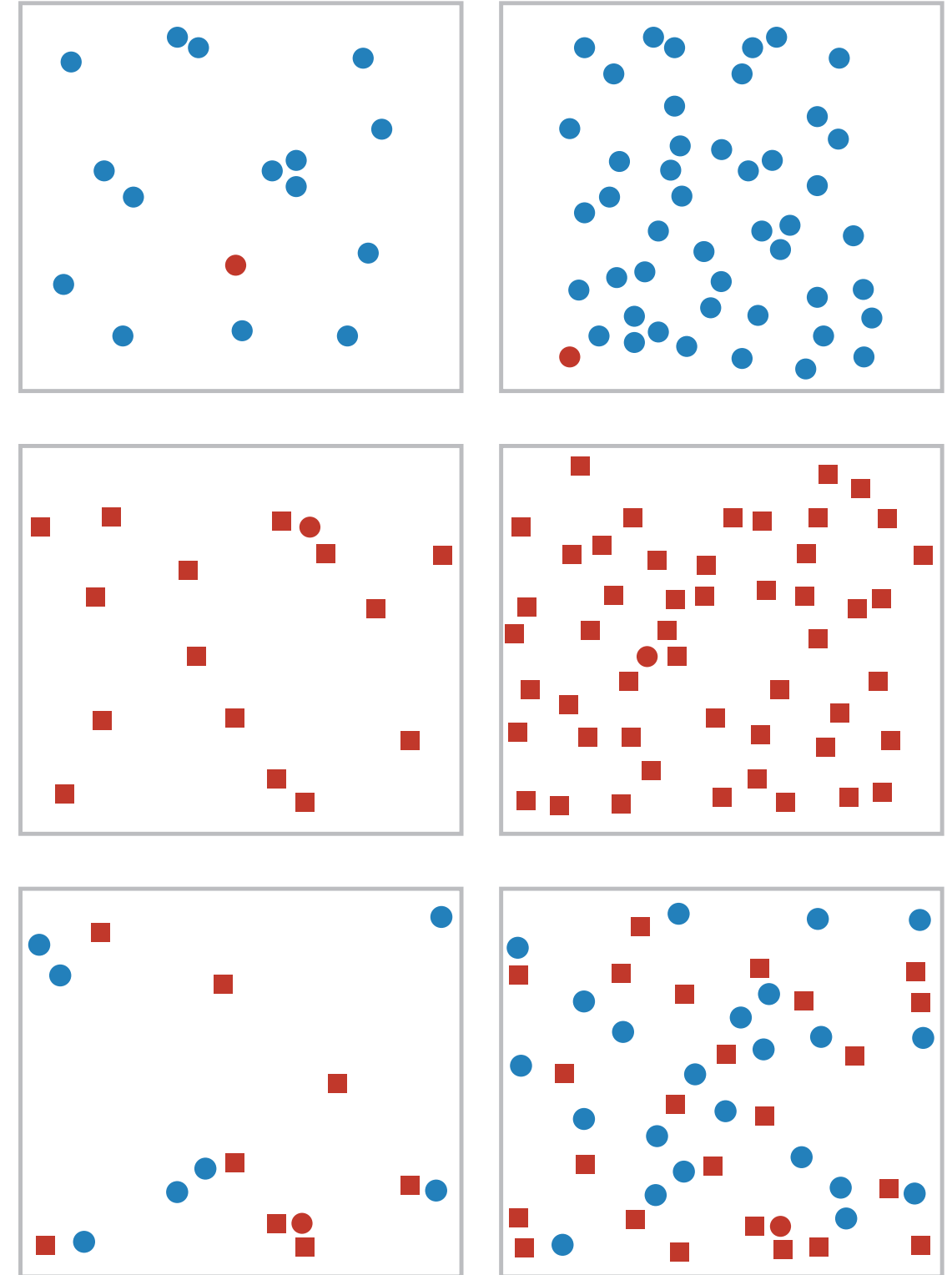


Major interference

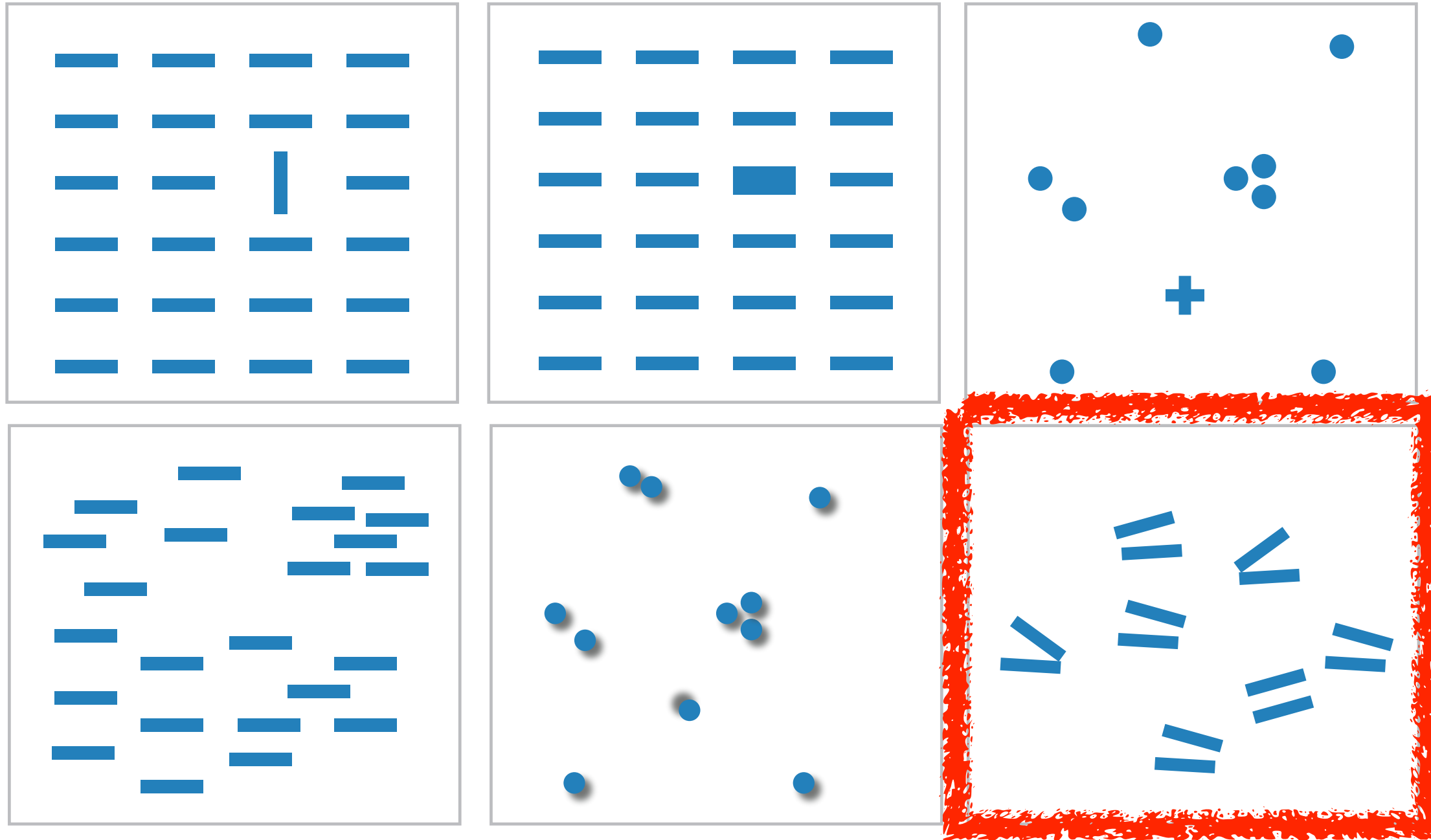
4 groups total:
integral hue

Popout

- find the red dot
 - how long does it take?
- parallel processing on many individual channels
 - speed independent of distractor count
 - speed depends on channel and amount of difference from distractors
- serial search for (almost all) combinations
 - speed depends on number of distractors



Popout



- many channels: tilt, size, shape, proximity, shadow direction, ...
- but not all! parallel line pairs do not pop out from tilted pairs

Grouping

- containment
- connection

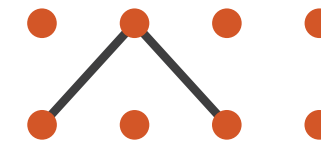
- proximity
 - same spatial region
- similarity
 - same values as other categorical channels

Marks as Links

➔ Containment



➔ Connection



➔ Identity Channels: Categorical Attributes

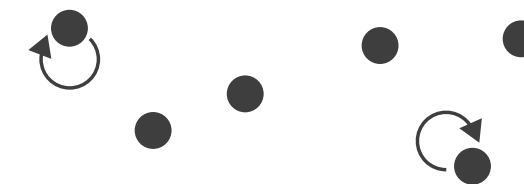
Spatial region



Color hue



Motion



Shape

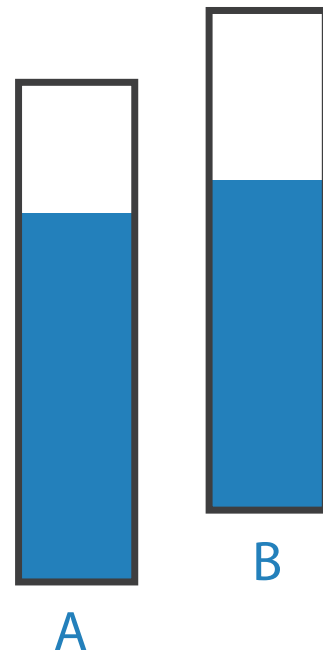


Relative vs. absolute judgements

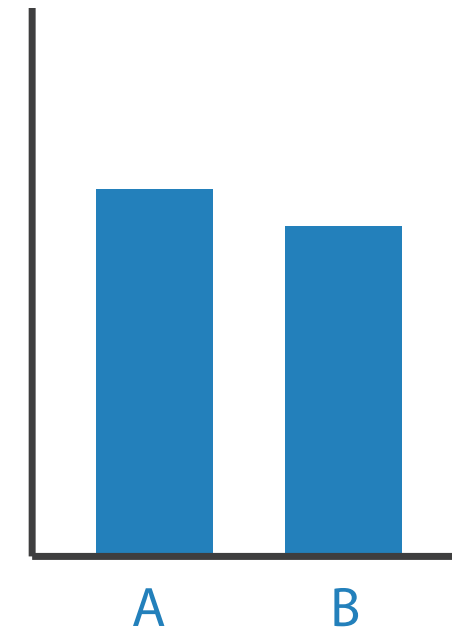
- perceptual system mostly operates with relative judgements, not absolute
 - that's why accuracy increases with common frame/scale and alignment
 - Weber's Law: ratio of increment to background is constant
 - filled rectangles differ in length by 1:9, difficult judgement
 - white rectangles differ in length by 1:2, easy judgement



length



position along
unaligned
common scale



position along
aligned scale

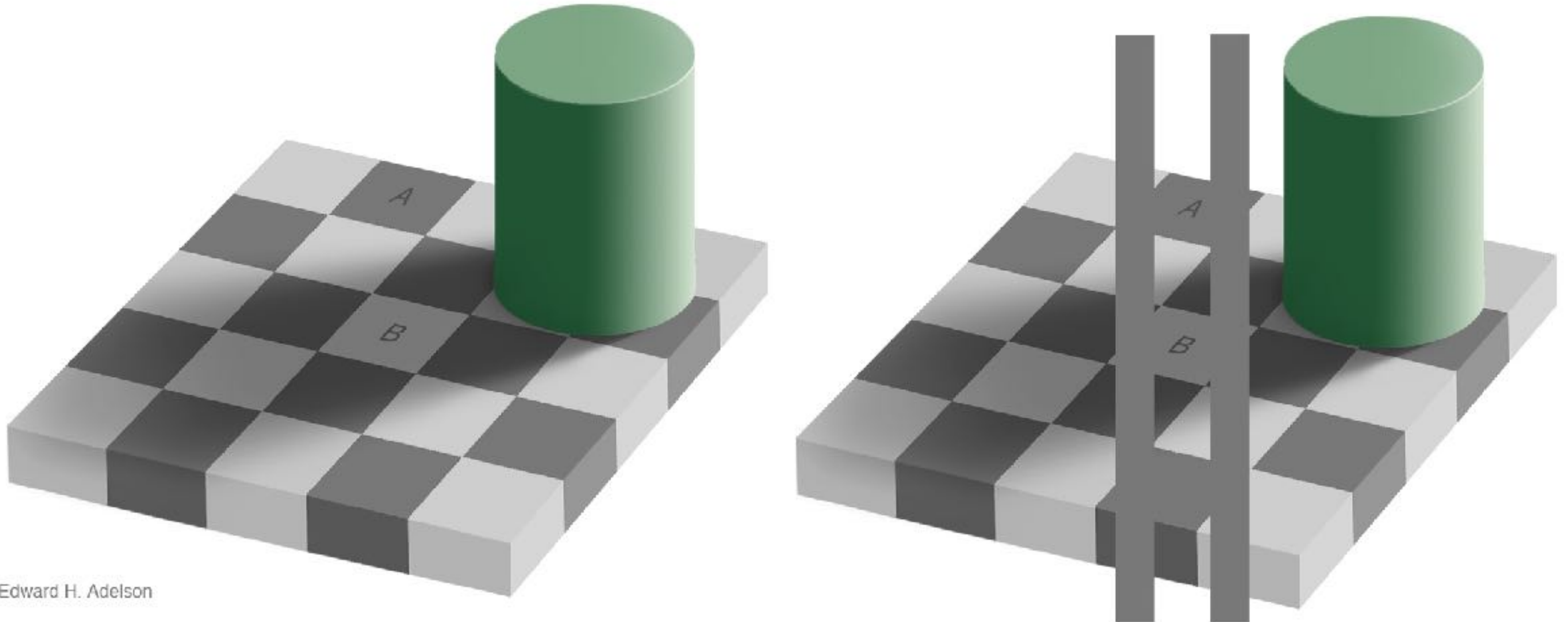
Factors affecting accuracy

- alignment
- distractors
- distance
- common scale



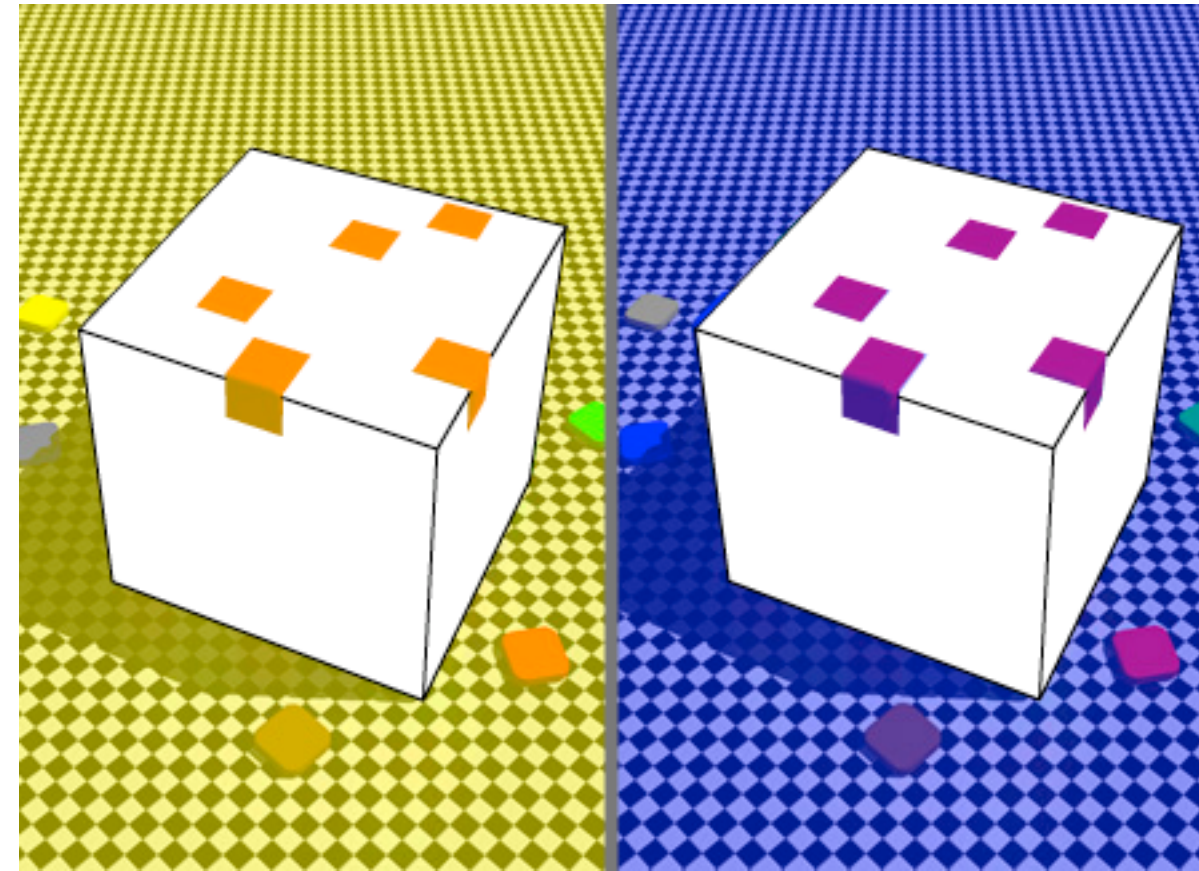
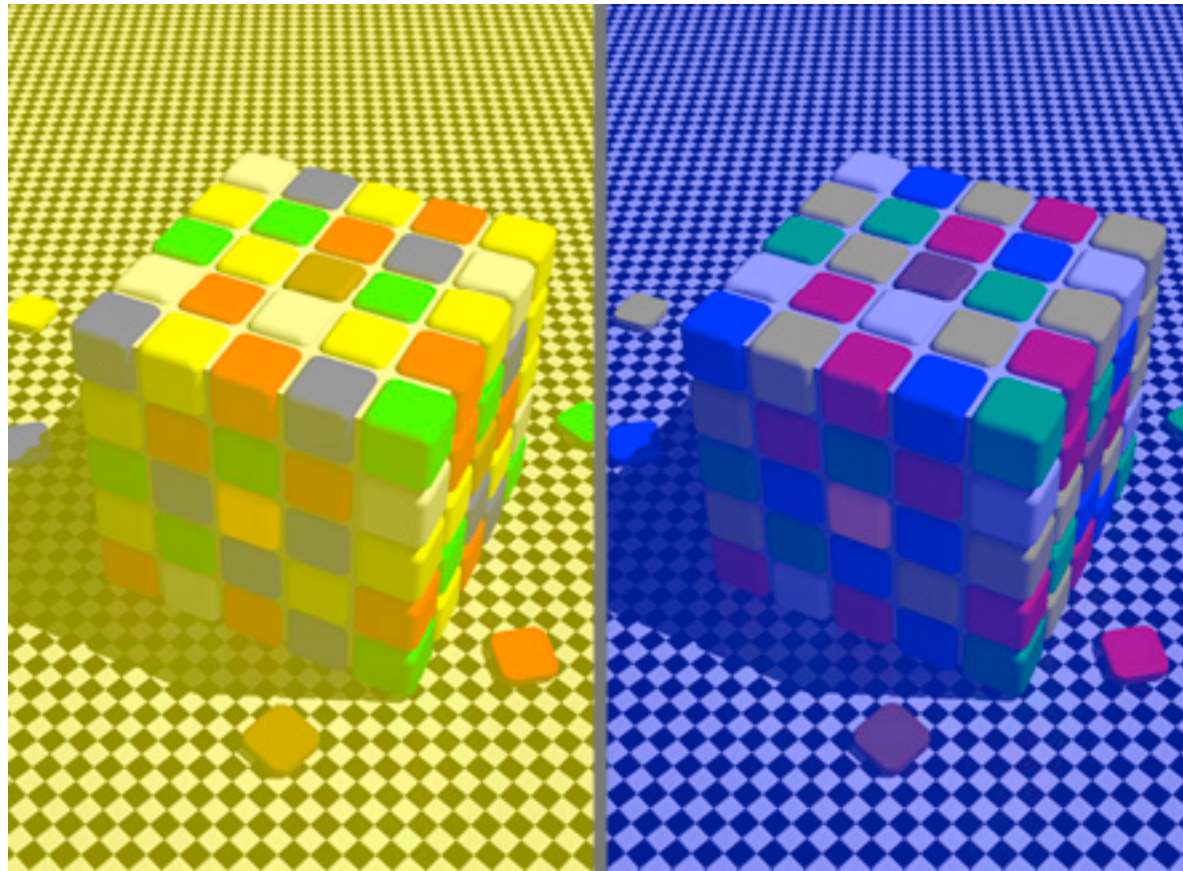
Relative luminance judgements

- perception of luminance is contextual based on contrast with surroundings



Relative color judgements

- color constancy across broad range of illumination conditions



Upcoming

- D3 videos to watch, week 3
 - Making a Bar Chart with D3 and SVG [30 min]
- Quiz 2, due by Fri Jan 17, 8am
- labs start this week!
 - Fri 9-10, 11-12, 4-5
 - strongly recommended but optional: we do not track attendance
 - TA office hours for individual consultation and help
 - TAs will typically alternate weeks
 - if you can't register, try attending the one you want
 - seats for registered students first, but may be room
- Foundations Exercise 2 out, due Wed Jan 22
- Programming Exercise 1 out, due Wed Jan 29

Credits

- Visualization Analysis and Design (Ch 5)
- Alex Lex & Miriah Meyer, <http://dataviscourse.net/>