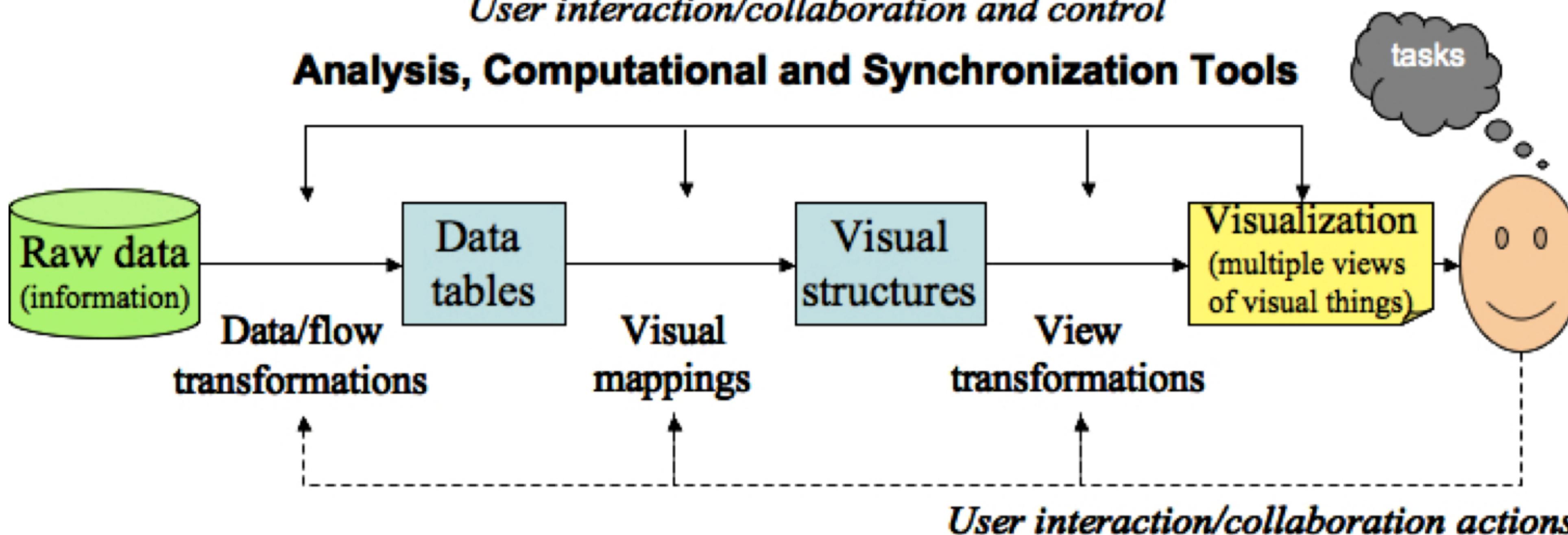


A wide-angle photograph of a mountain river scene. In the foreground, large, dark, textured rocks are scattered along the bank. The river flows from the background towards the viewer, with white rapids and greenish-blue water. The banks are lined with dense forests of tall evergreen trees. In the far distance, more mountains are visible under a sky filled with soft, grey clouds.

data
representation

User interaction/collaboration and control

Analysis, Computational and Synchronization Tools

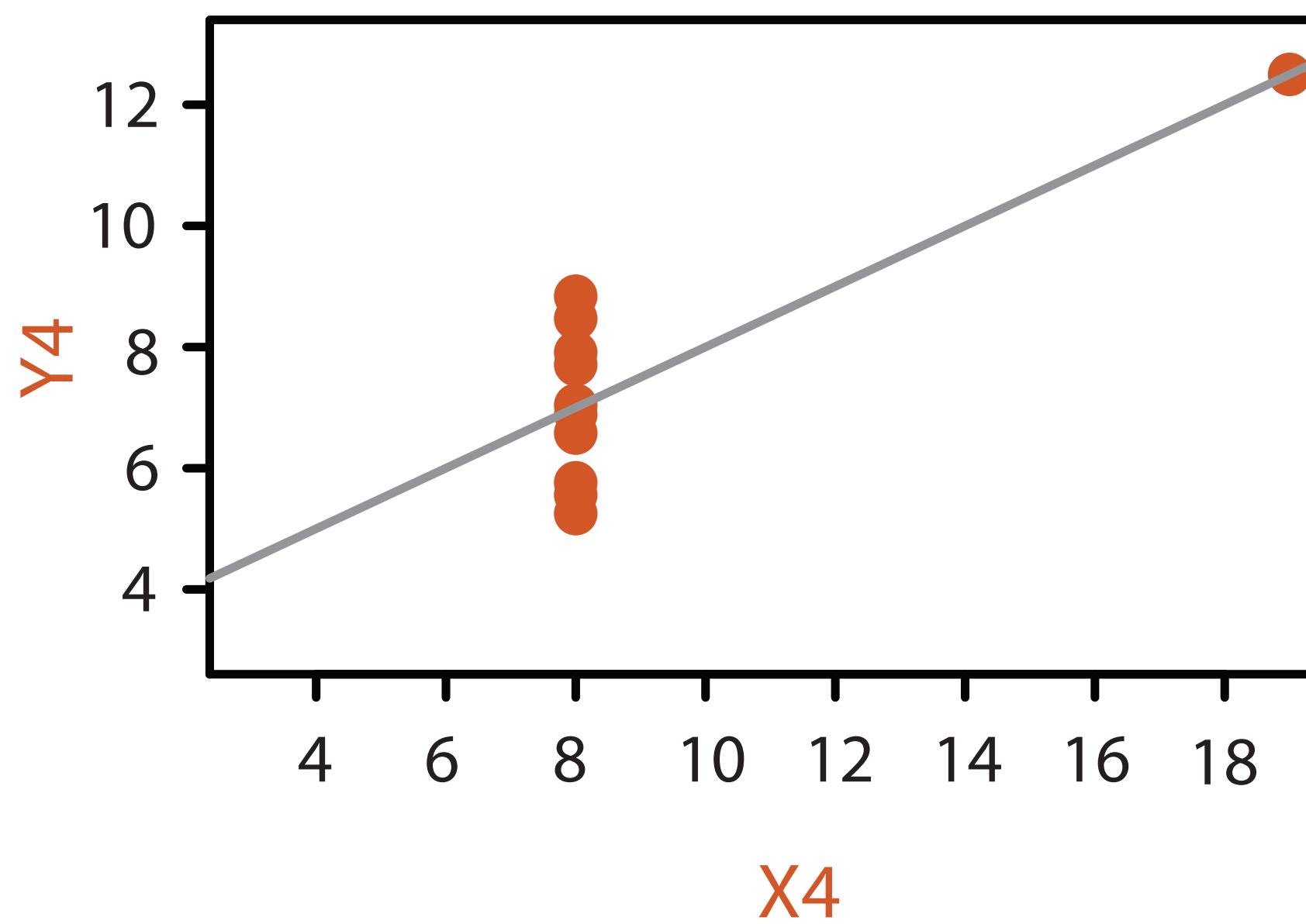
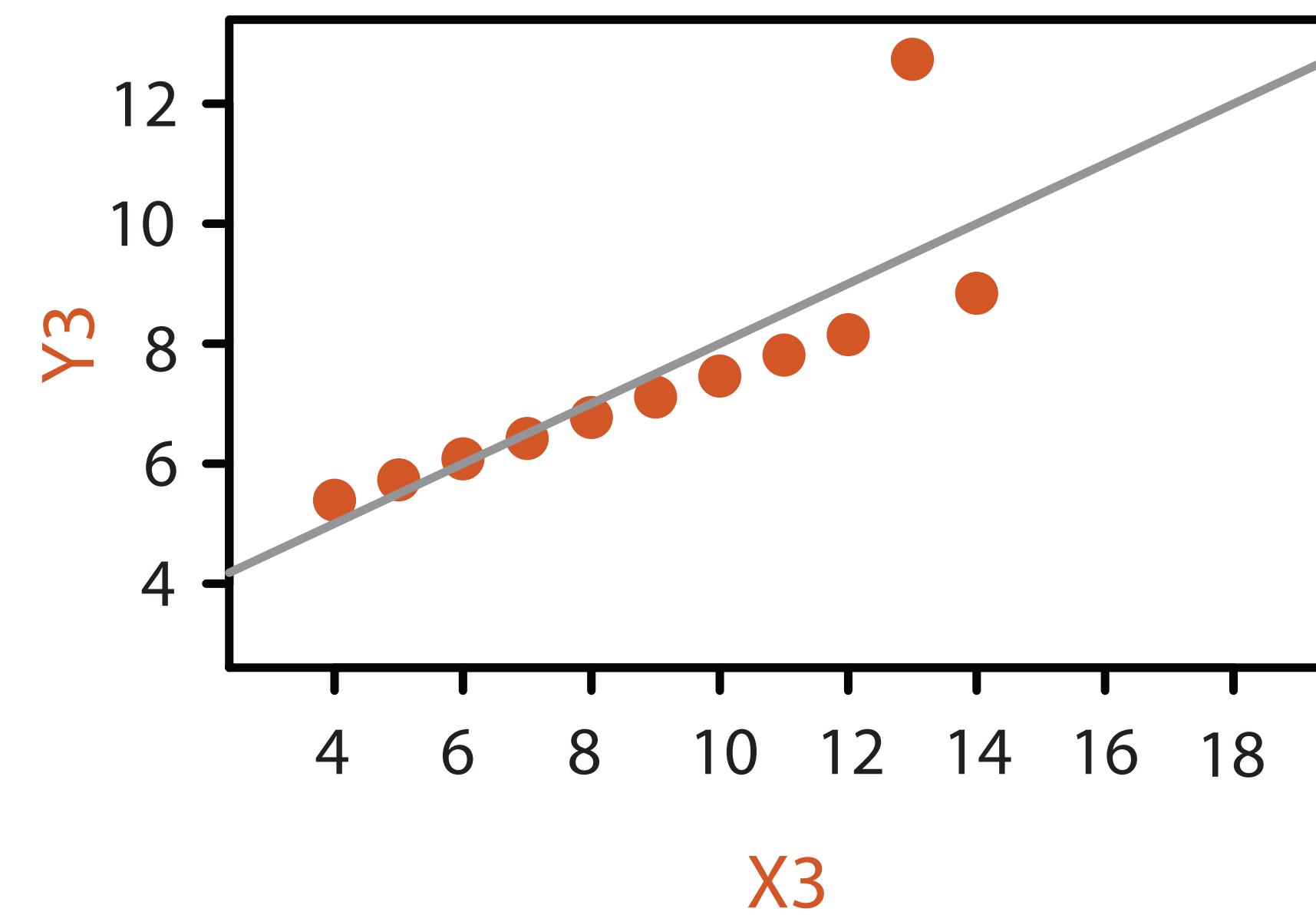
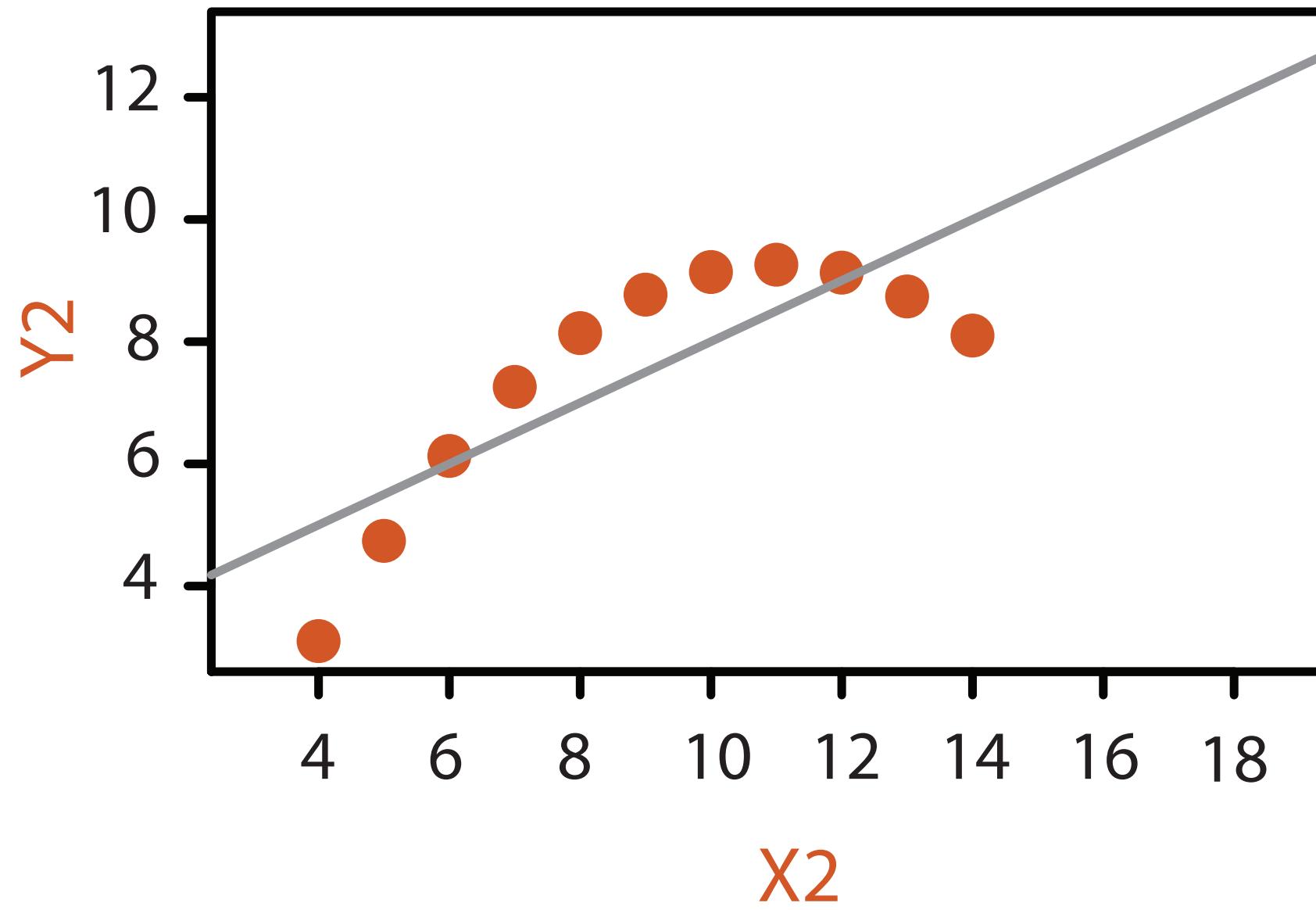
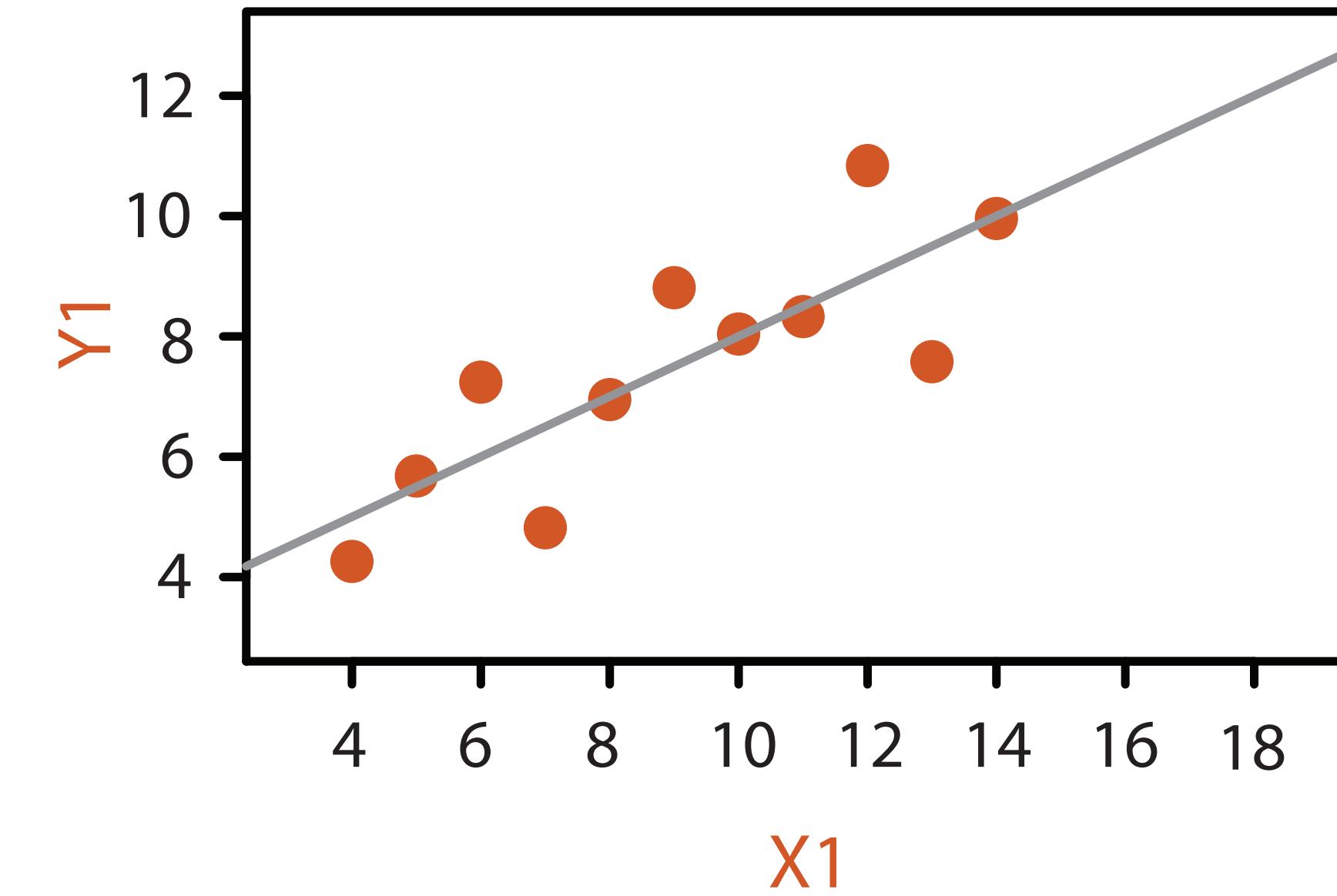


10.0	8.04
8.0	6.95
13.0	7.58
9.0	8.81
11.0	8.33
14.0	9.96
6.0	7.24
4.0	4.26
12.0	10.84
7.0	4.82
5.0	5.68

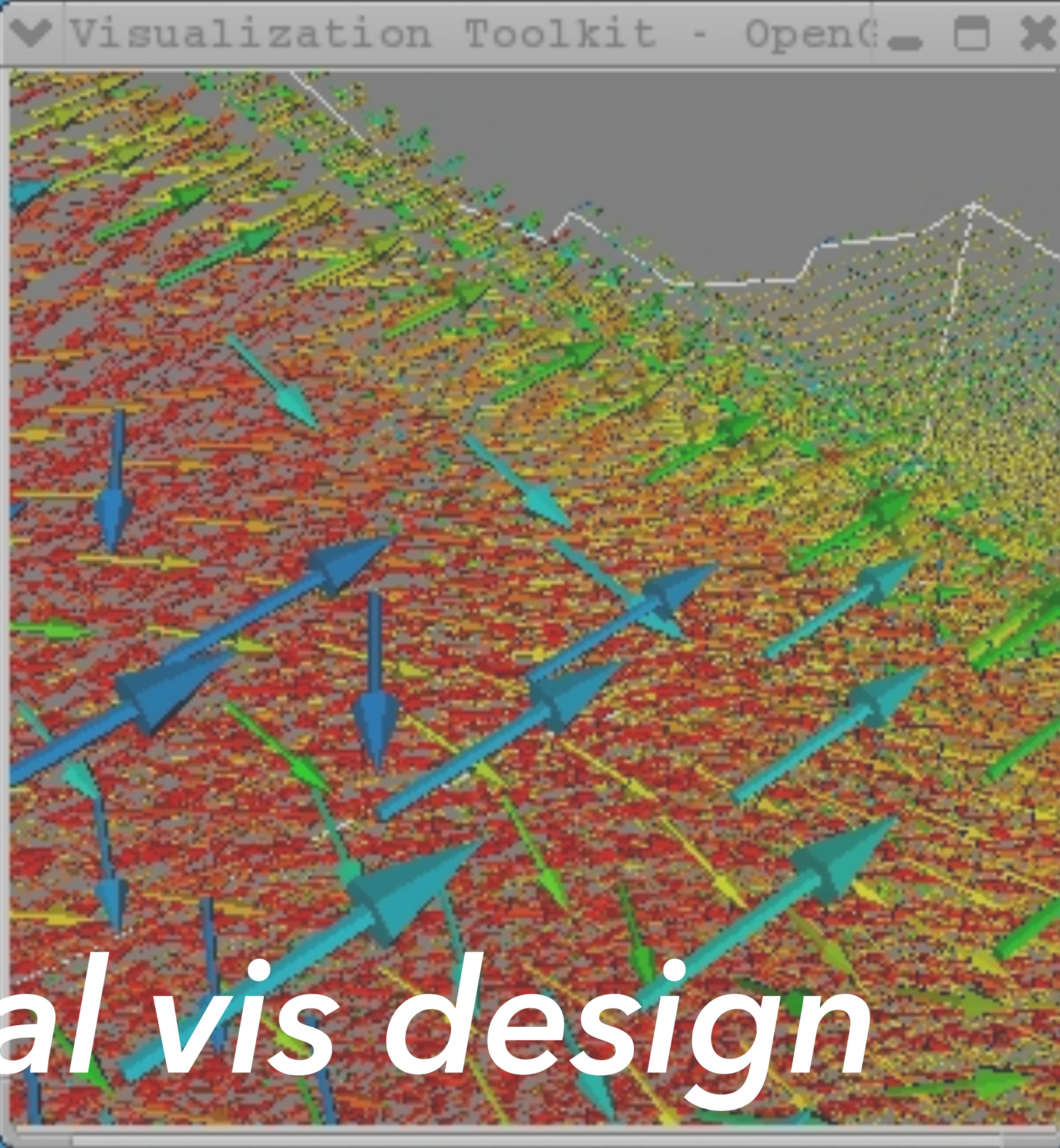
	10.0	8.04
	8.0	6.95
	13.0	7.58
	9.0	8.81
	11.0	8.33
	14.0	9.96
	6.0	7.24
	4.0	4.26
	12.0	10.84
	7.0	4.82
	5.0	5.68
Mean	9.0	7.5
Variance	10.0	3.75

	1		2		3		4	
	X	Y	X	Y	X	Y	X	Y
	10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
	8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
	13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
	9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
	11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
	14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
	6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
	4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
	12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
	7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
	5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89
Mean	9.0	7.5	9.0	7.5	9.0	7.5	9.0	7.5
Variance	10.0	3.75	10.0	3.75	10.0	3.75	10.0	3.75

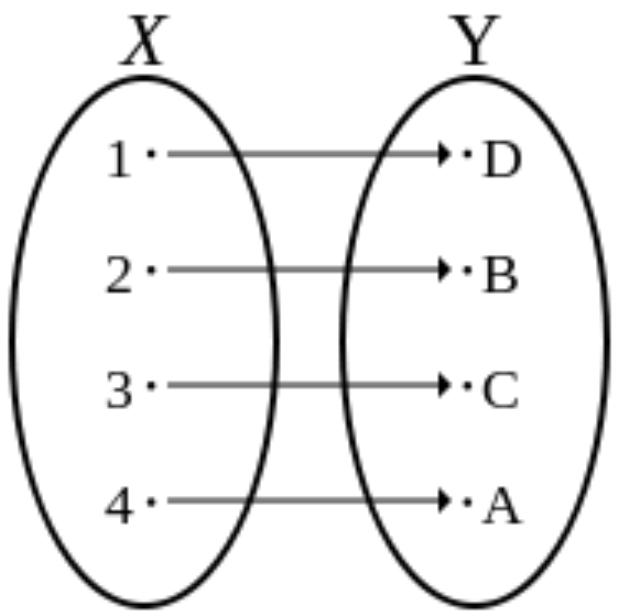
	1		2		3		4	
	X	Y	X	Y	X	Y	X	Y
	10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
	8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
	13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
	9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
	11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
	14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
	6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
	4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
	12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
	7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
	5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89
Mean	9.0	7.5	9.0	7.5	9.0	7.5	9.0	7.5
Variance	10.0	3.75	10.0	3.75	10.0	3.75	10.0	3.75
Correlation	0.816		0.816		0.816		0.816	



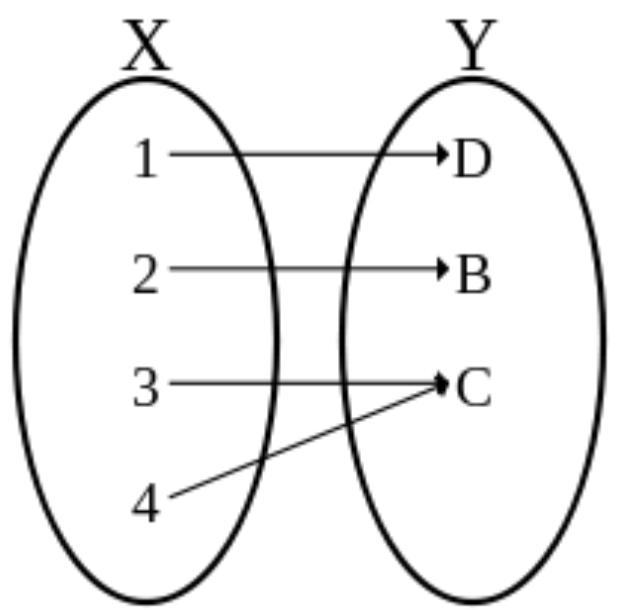
R



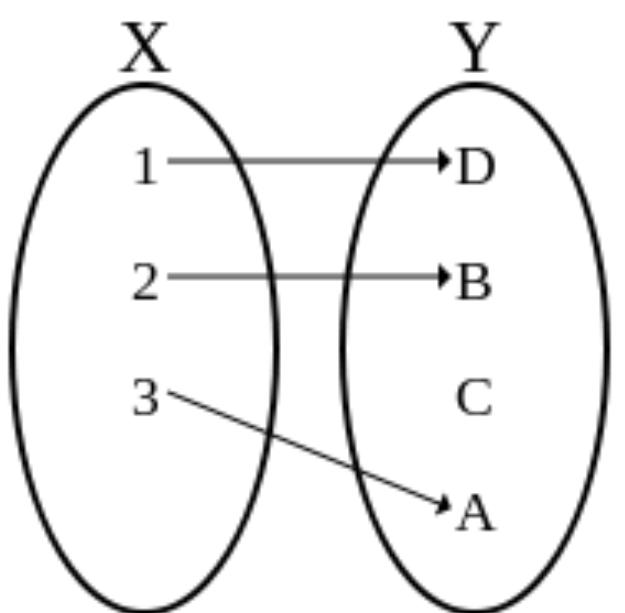
Key question: how
to map data to
visuals?



**Bijection (one visual attribute,
one data attribute)**



**Surjection (multiple visual attribute
to one data attribute)**



**Injection (One to one mapping, but
not all data elements are mapped)**

Set Theory

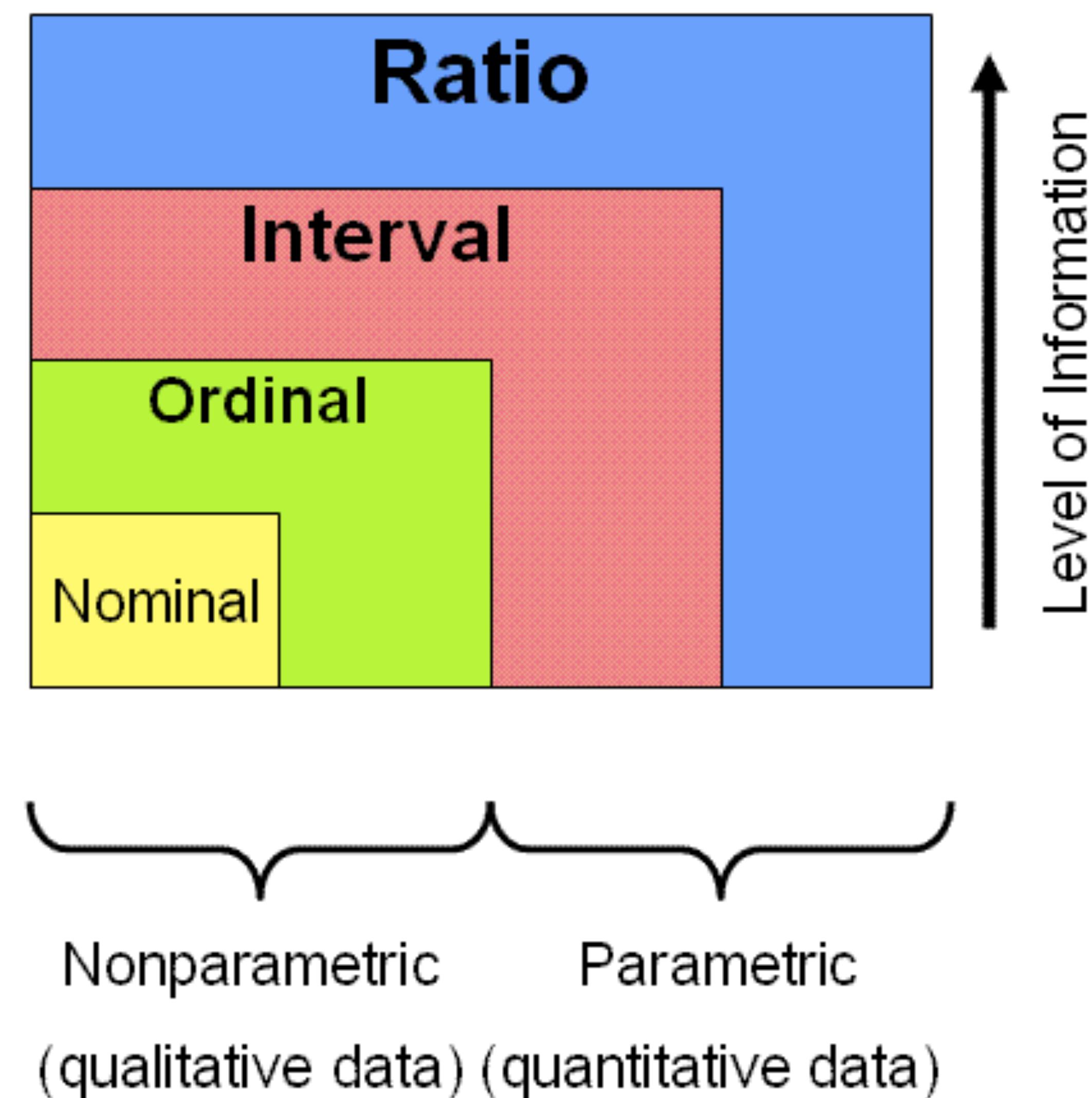
What happens when

Data Vars > Visual Vars ?

What happens when

Visual Vars > Data Vars ?

Data Attributes



Non-ordered and non-numeric

AKA categorical data

[‘apple’, ‘pear’, ‘banana’]

nominal

Ordered, not necessarily numeric

[1st, 3rd, 5th, 7th]

1st -> 3rd

['G', 'PG', 'PG-13', 'R']

PG -> R

ordinal

Ordered, not necessarily numeric

[1st, 3rd, 5th, 7th]

1st -> 3rd

['G', 'PG', 'PG-13', 'R']

PG -> R

length is not meaningful

ordinal

Ordered, numeric, not ratio-able

['Jan 12', 'Jan 20']

Jan 12/Jan 20 = ???

['17°', '44°', '23°', '30°']

$23^\circ / 30^\circ = ???$

interval

Ordered, numeric, ratio-able (has a “true” 0)

[1, 3, 5, 7]

[5'8", 6'1", 5'4"]

ratio

$Q \rightarrow 0$

$[0-100] \rightarrow [A, B, C, D, F]$

Ratio /
Interval (Q)

Ordinal

Nominal

transforms

$Q \rightarrow O$

$[0-100] \rightarrow [A, B, C, D, F]$

Ratio /
Interval (O)

$O \rightarrow N$

$[A, B, C, D, F] \rightarrow [B, C, F, D, A]$

Ordinal

Nominal

transforms

$Q \rightarrow O$

$[0-100] \rightarrow [A, B, C, D, F]$

Ratio /
Interval (O)

$O \rightarrow N$

$[A, B, C, D, F] \rightarrow [B, C, F, D, A]$

Ordinal

$N \rightarrow O$

$["Jack", "Alex"] \rightarrow ["Alex", "Jack"]$

Nominal

transforms

$\underline{Q} \rightarrow O$

$[0-100] \rightarrow [A, B, C, D, F]$

Ratio /
Interval (\underline{Q})

$O \rightarrow N$

$[A, B, C, D, F] \rightarrow [B, C, F, D, A]$

Ordinal

$N \rightarrow O$

$["Jack", "Alex"] \rightarrow ["Alex", "Jack"]$

Nominal

$O \rightarrow Q$

$"Alex" + "Jack" \rightarrow 7 ???$

transforms

Nominal

$=$ \neq

Ordinal

$>$ $<$ \leq \geq

Interval

$+$ $-$

Ratio

$/$ $*$

operations

Nominal

$=$ \neq

Ordinal

$>$ $<$ \leq \geq

Interval

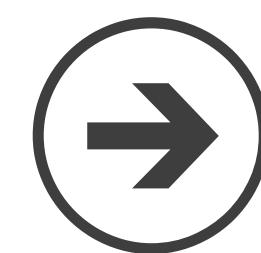
$+$ $-$

Ratio

$/$ $*$

consider a
distance function...

operations



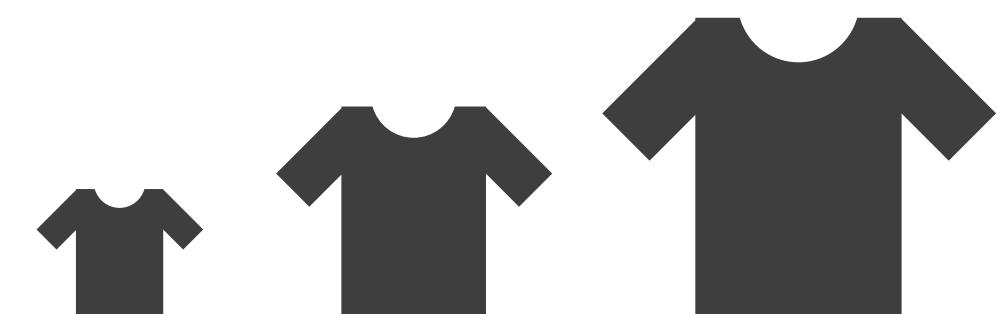
Attribute Types

→ Categorical



→ Ordered

→ *Ordinal*

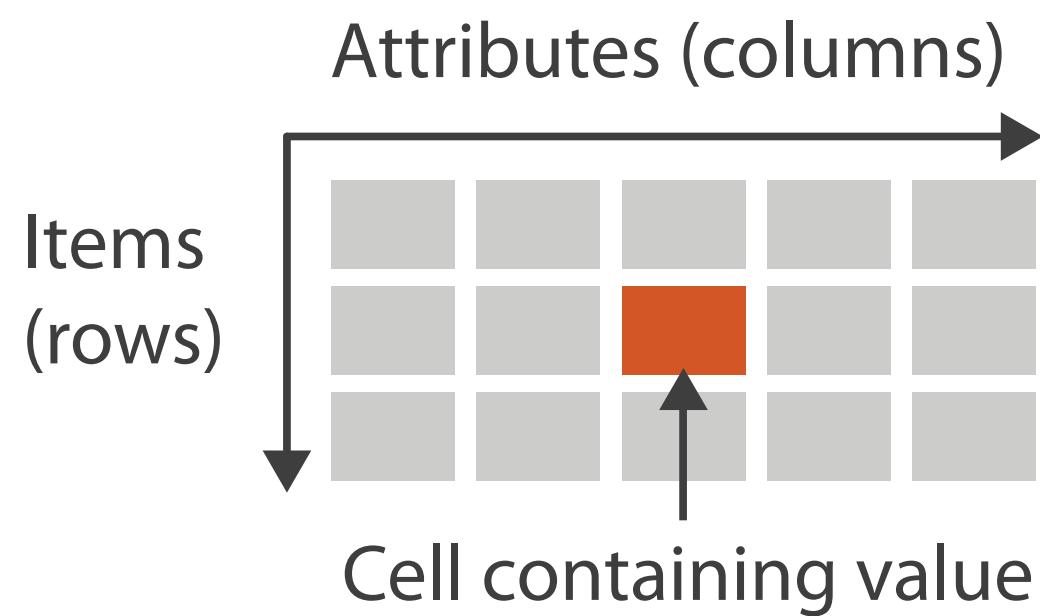


→ *Quantitative*

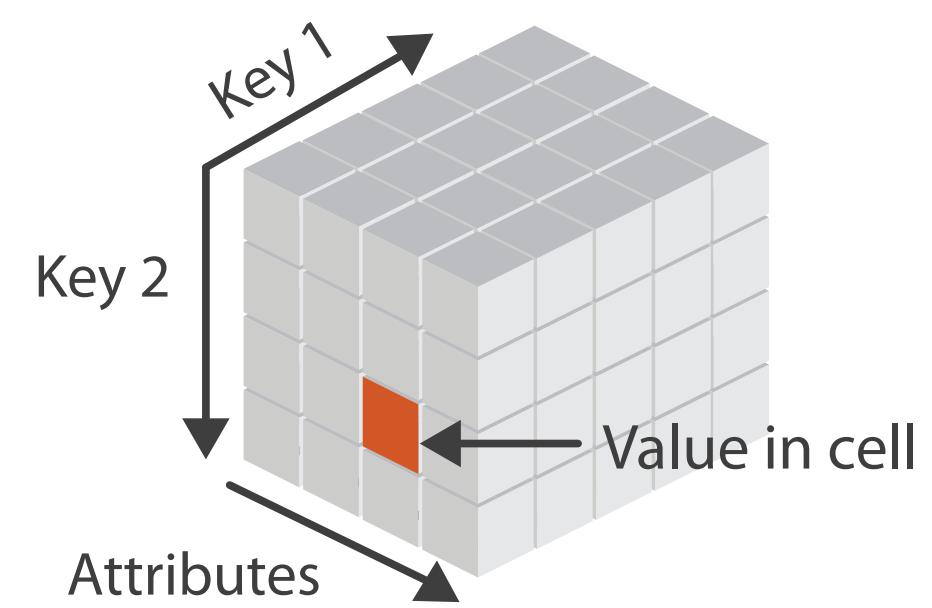


structure

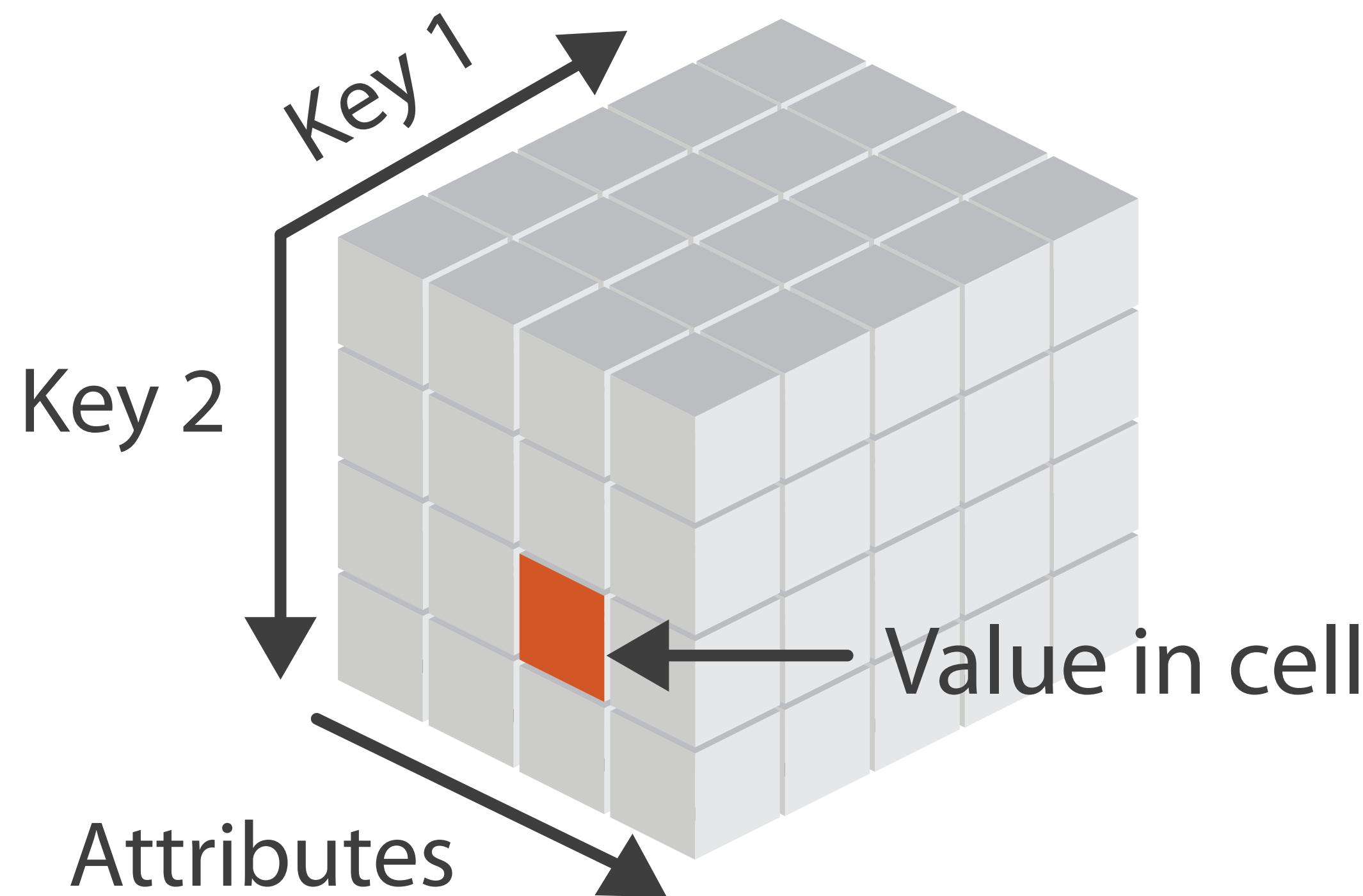
→ Tables



→ *Multidimensional Table*



→ *Multidimensional Table*



Datasets

➔ Data Types

→ Items

→ Attributes

→ Links

→ Positions

→ Grids

➔ Data and Dataset Types

Tables

Items

Attributes

Networks &
Trees

Items (nodes)

Links

Attributes

Fields

Grids

Positions

Attributes

Geometry

Items

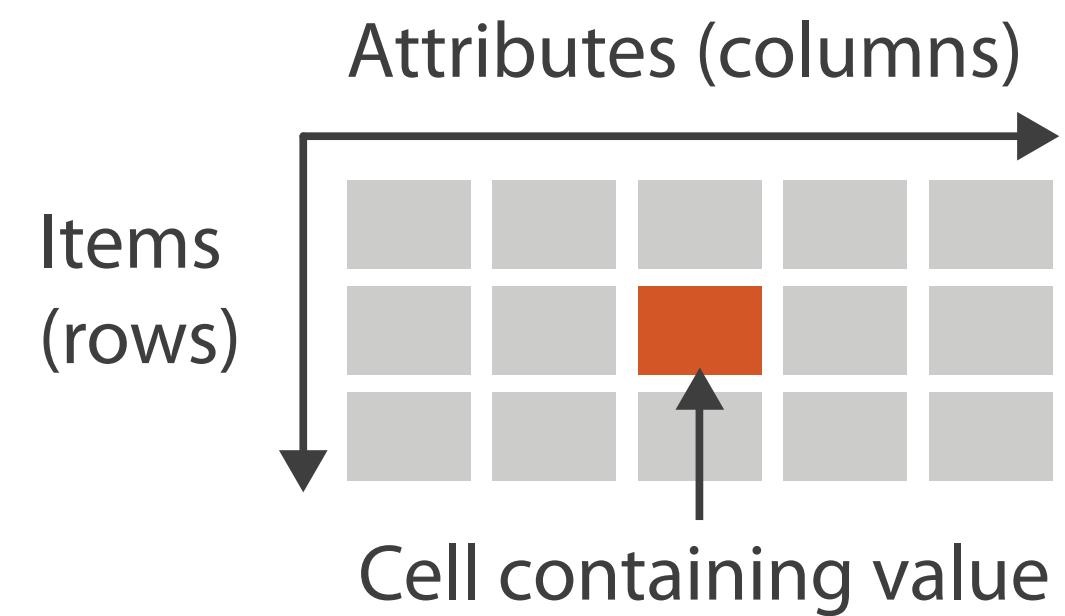
Positions

Clusters,
Sets, Lists

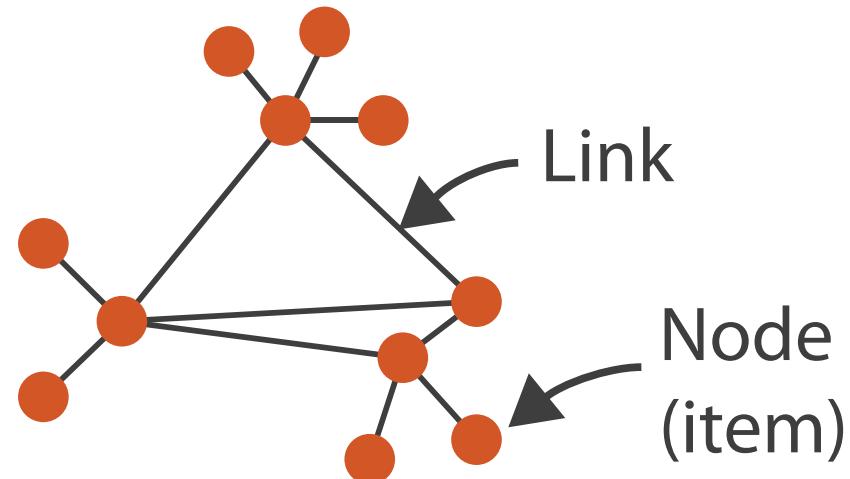
Items

→ Dataset Types

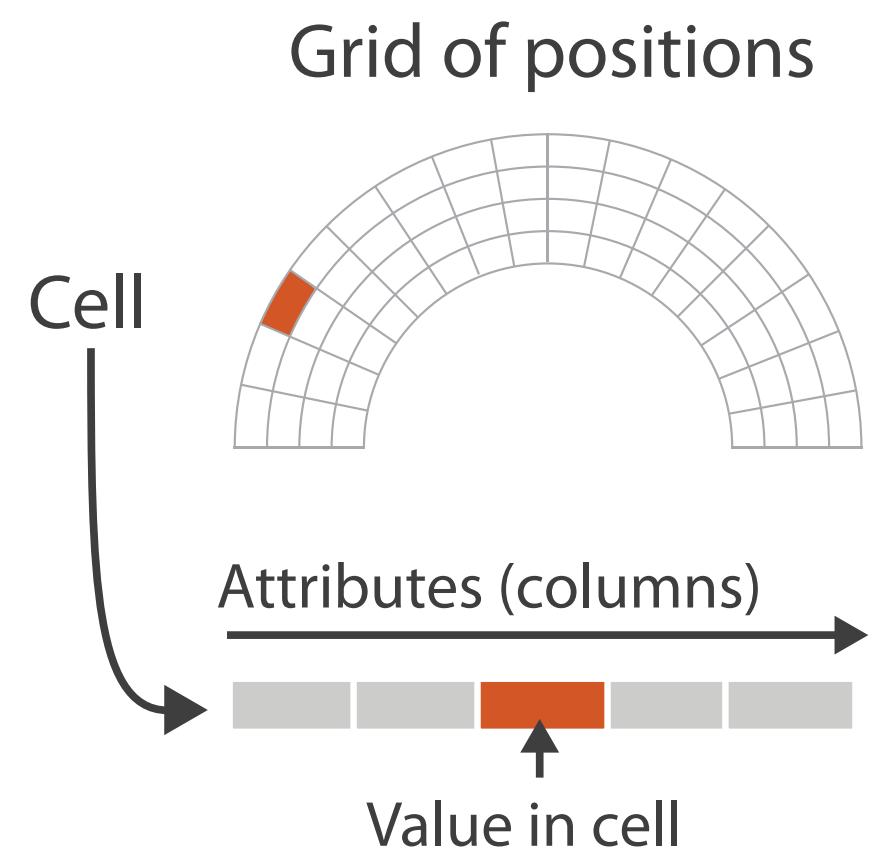
→ Tables



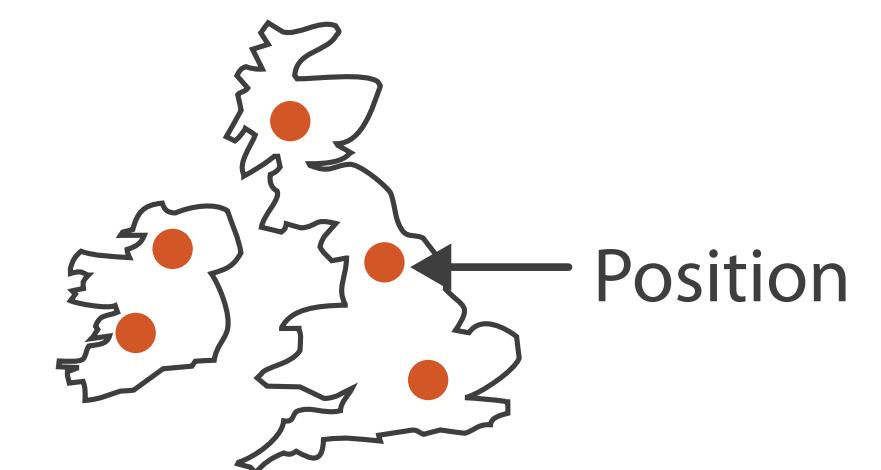
→ Networks



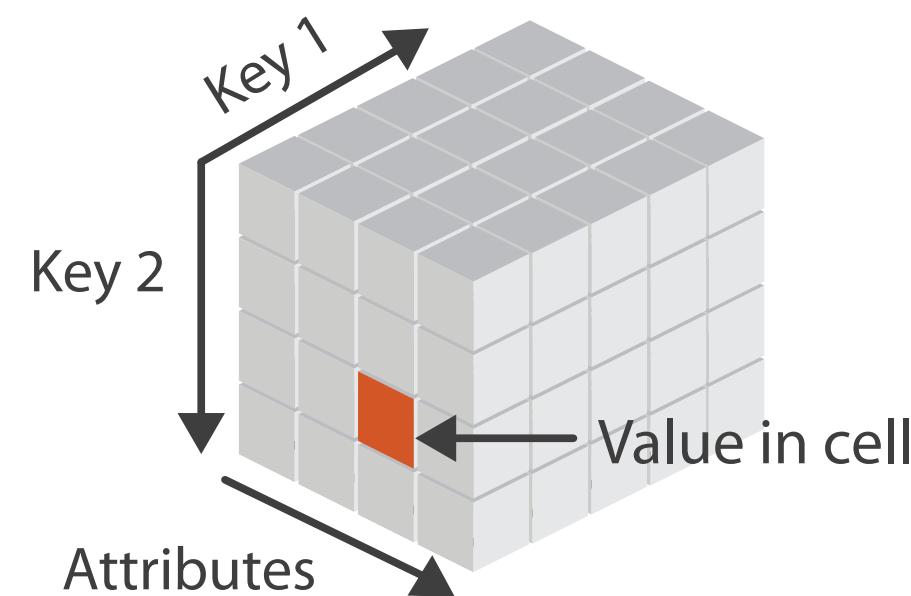
→ Fields (Continuous)



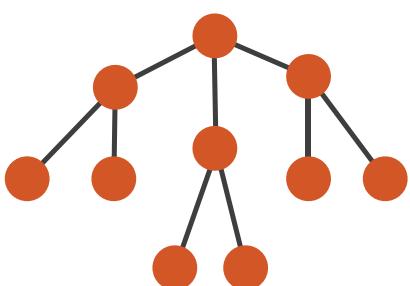
→ Geometry (Spatial)



→ Multidimensional Table



→ Trees



data shapes the
algorithm space

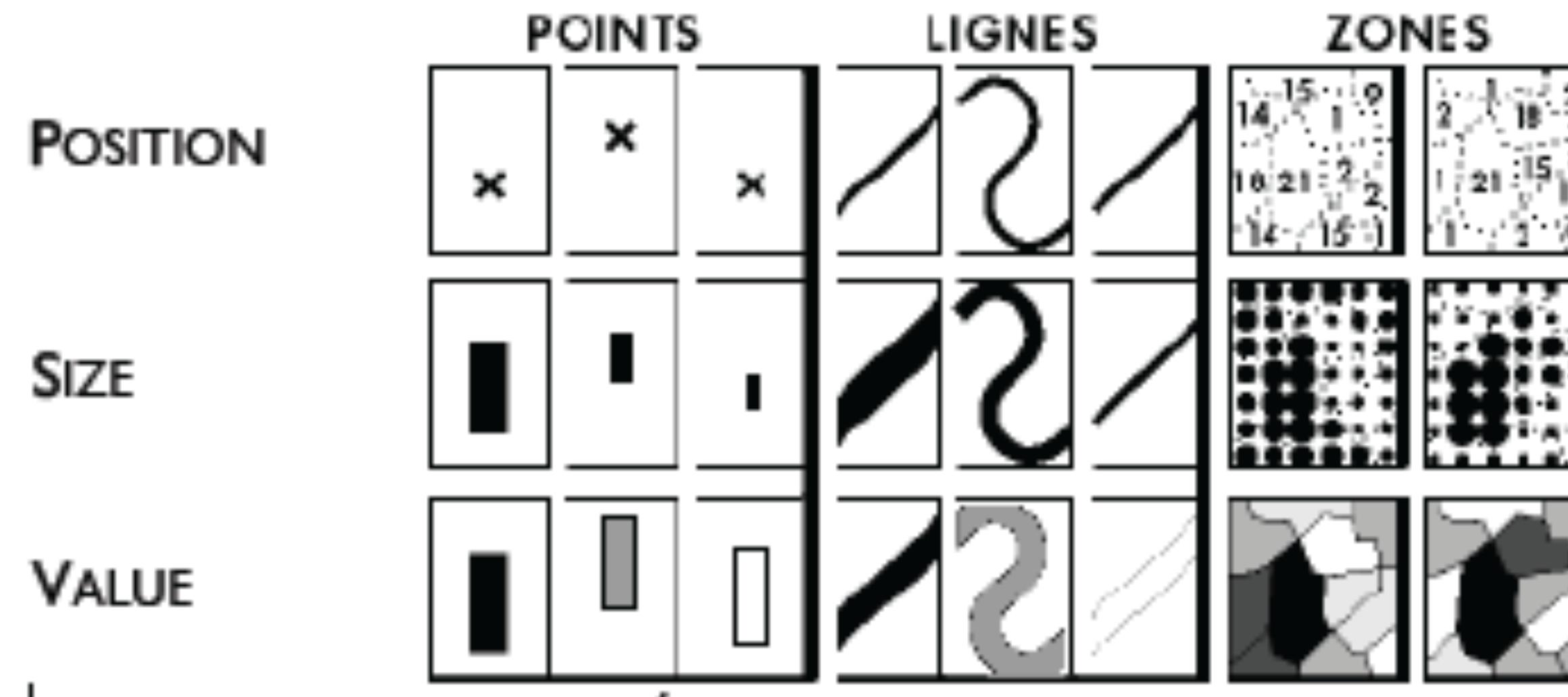
data shapes the
visual space

Further Reading

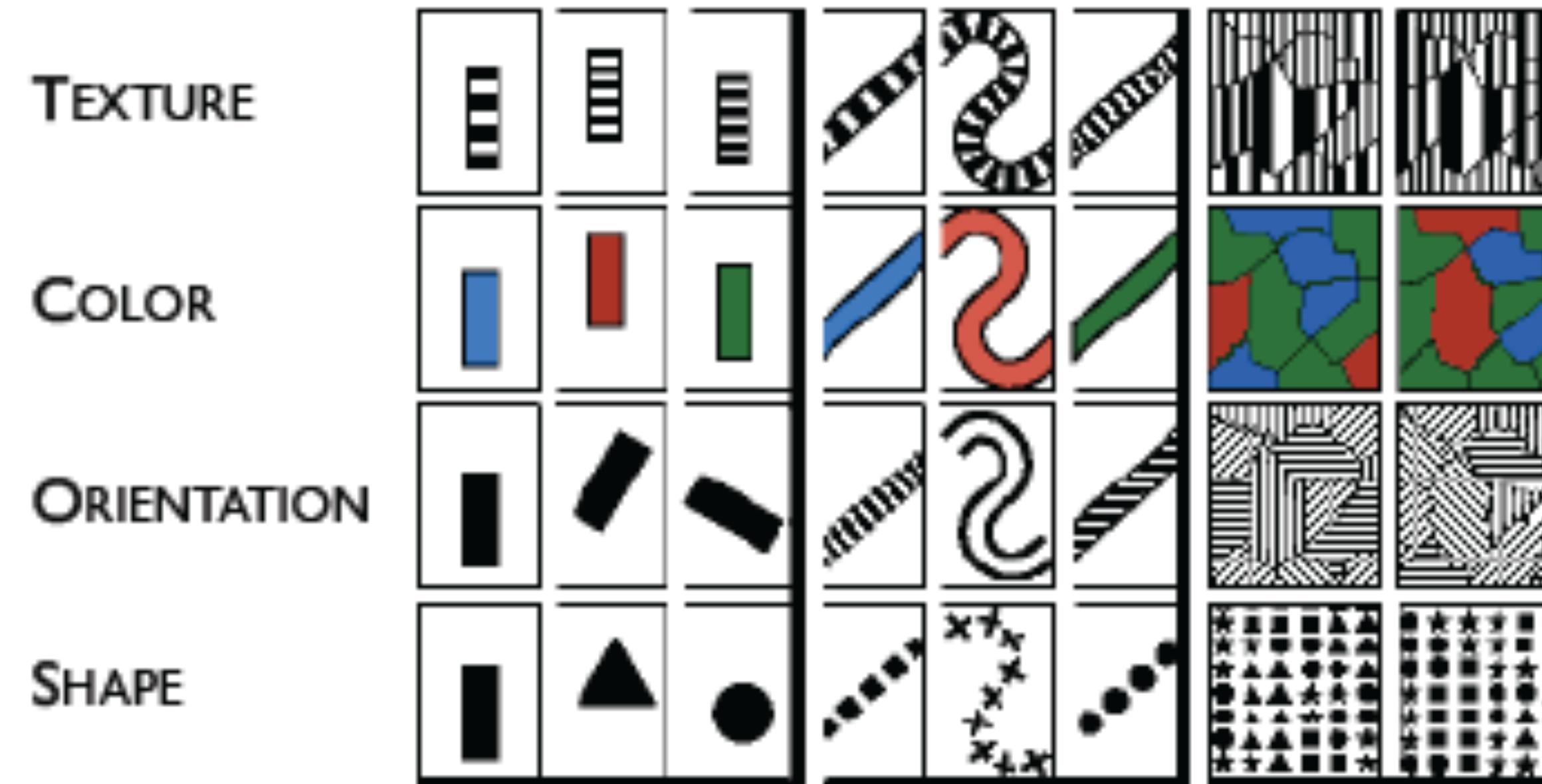
Stevens, Stanley Smith. "On the theory of scales of measurement." (1946).

Visual Attributes

LES VARIABLES DE L'IMAGE

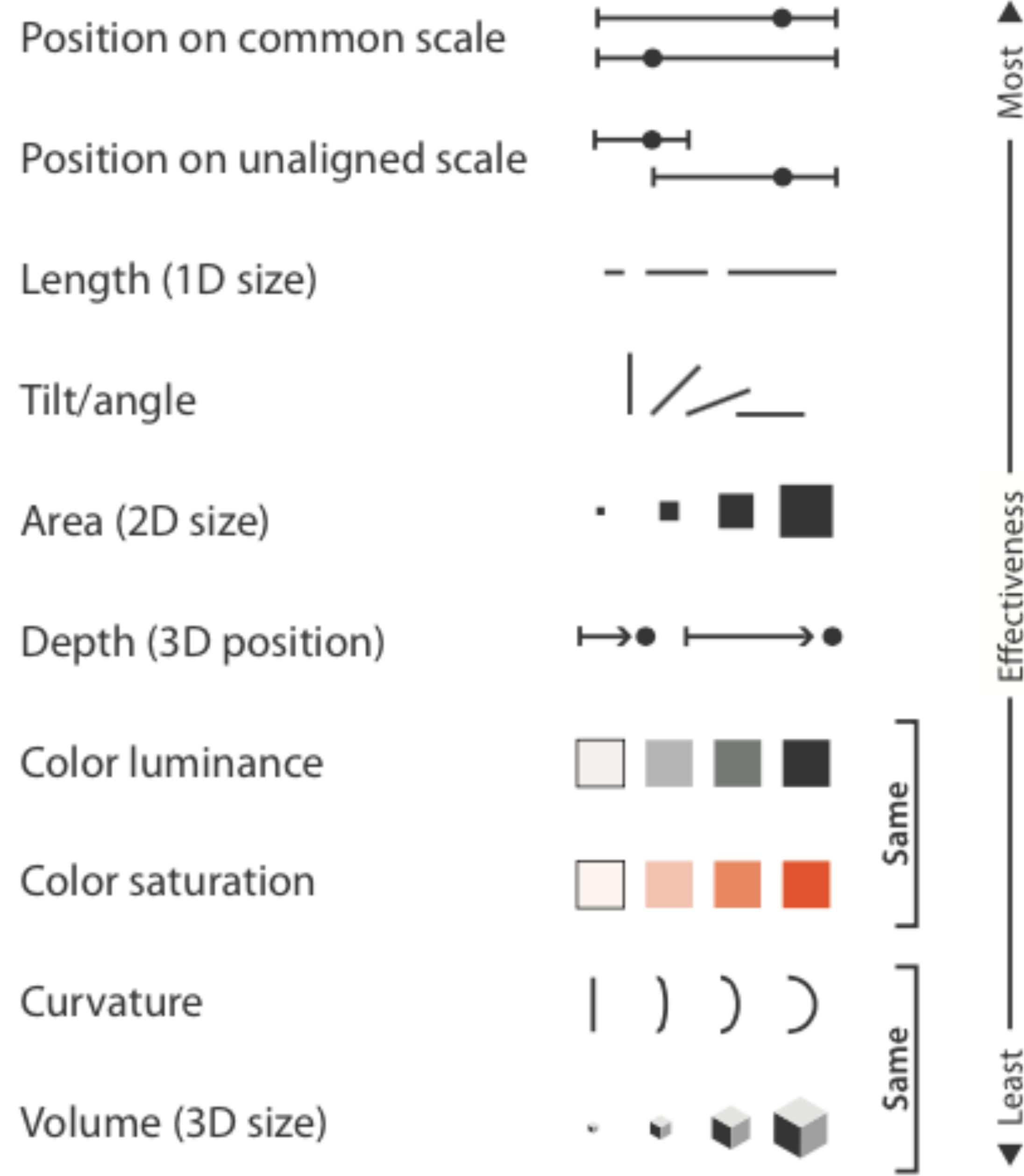


LES VARIABLES DE SÉPARATION DES IMAGES



Bertin, Sémiologie Graphique, '67

④ Magnitude Channels: Ordered Attributes



(pay attention to your how you judge these differences)

Position (Common Scale)



- scatterplots
- bar charts
- line charts
- ???

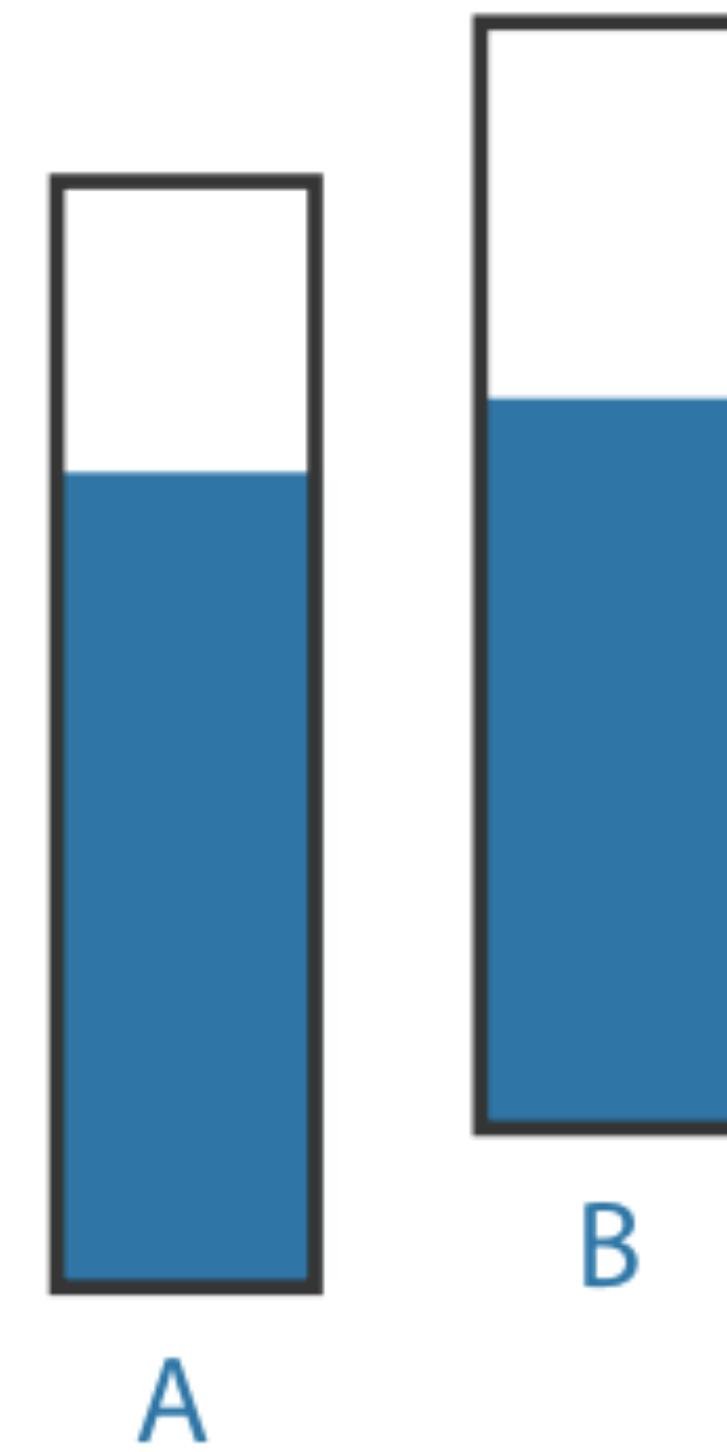
Position (Un-aligned Scale)



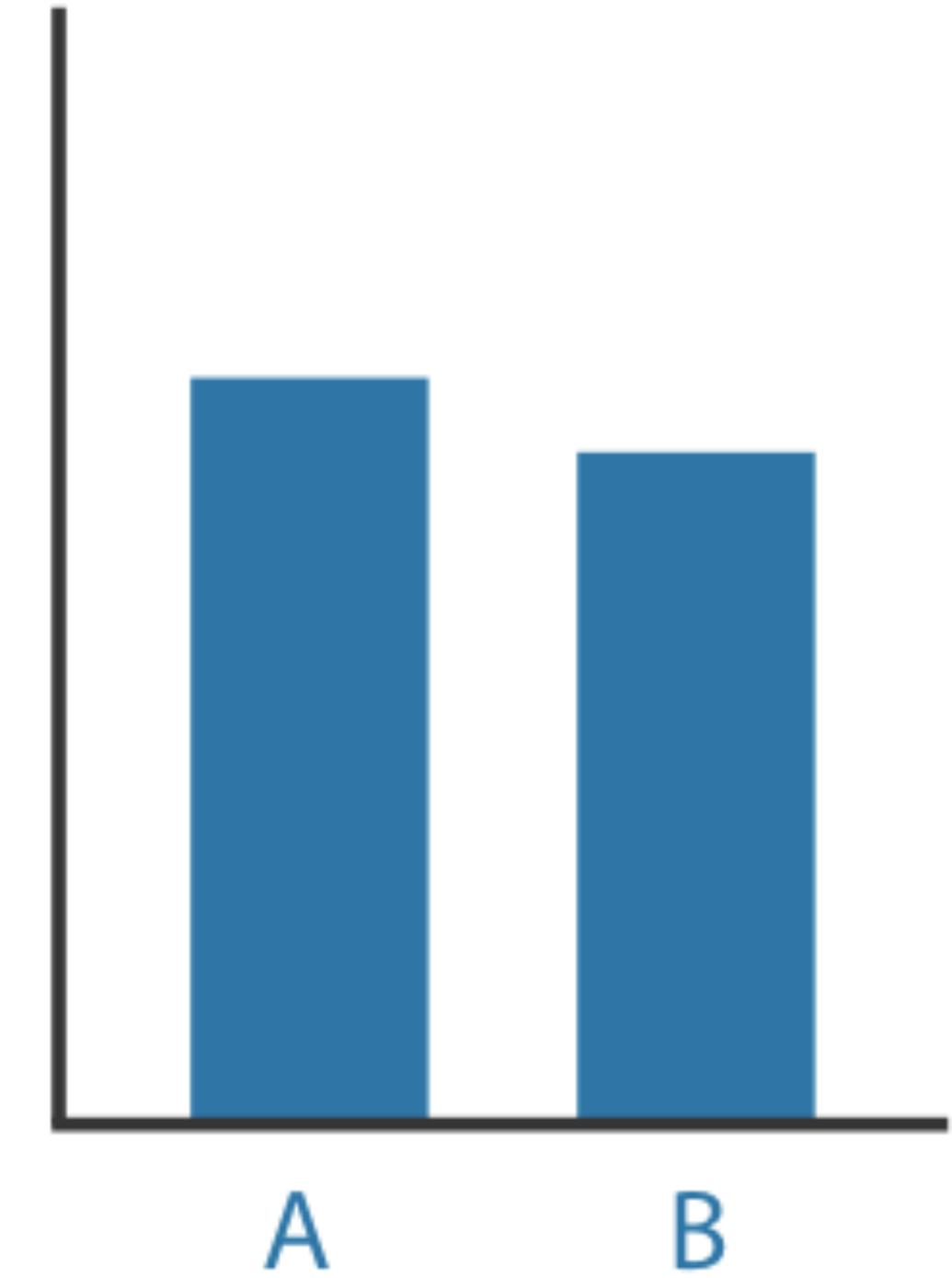
- stacked bars
- stacked area
- ???



Unframed
Unaligned

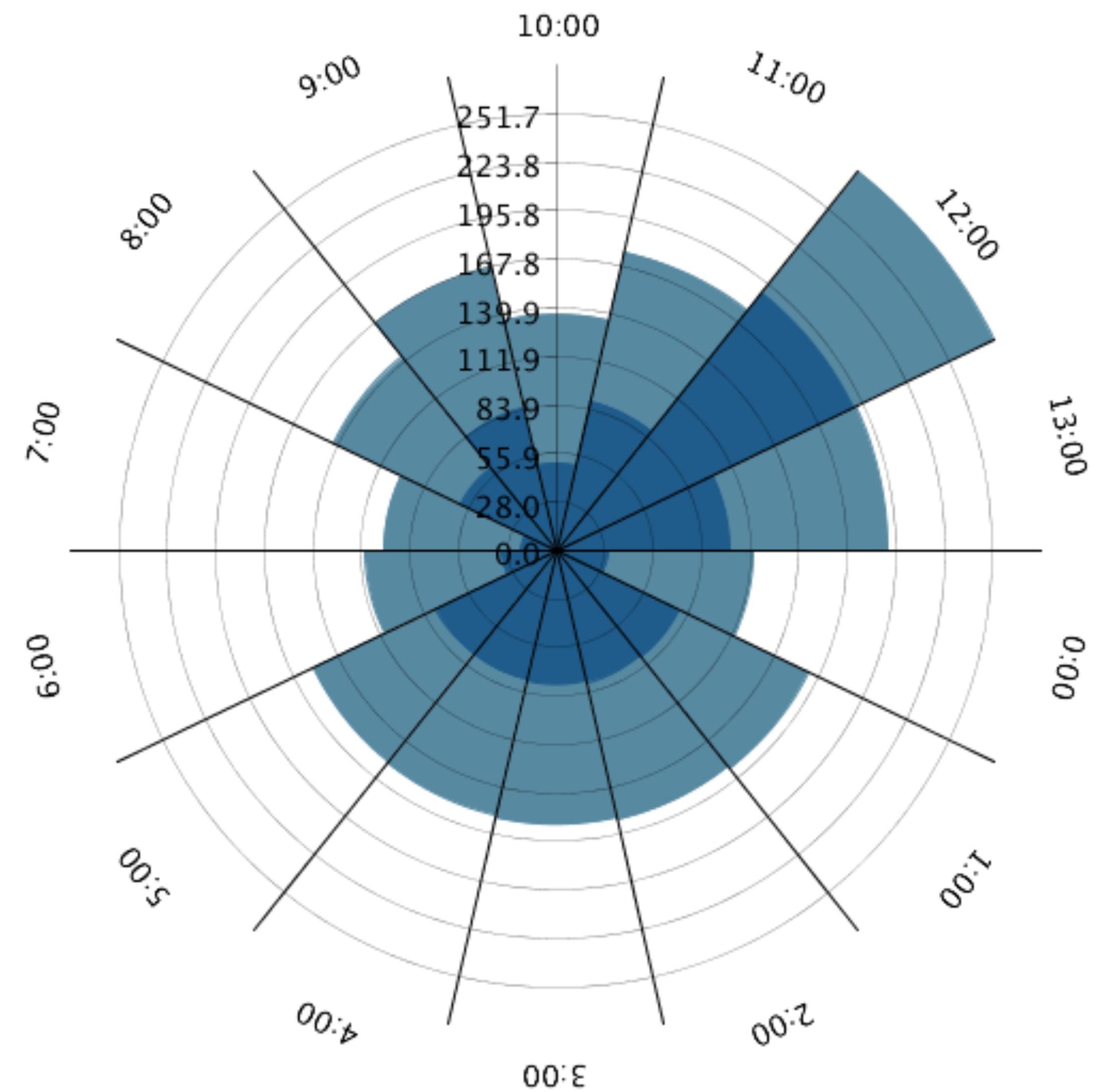
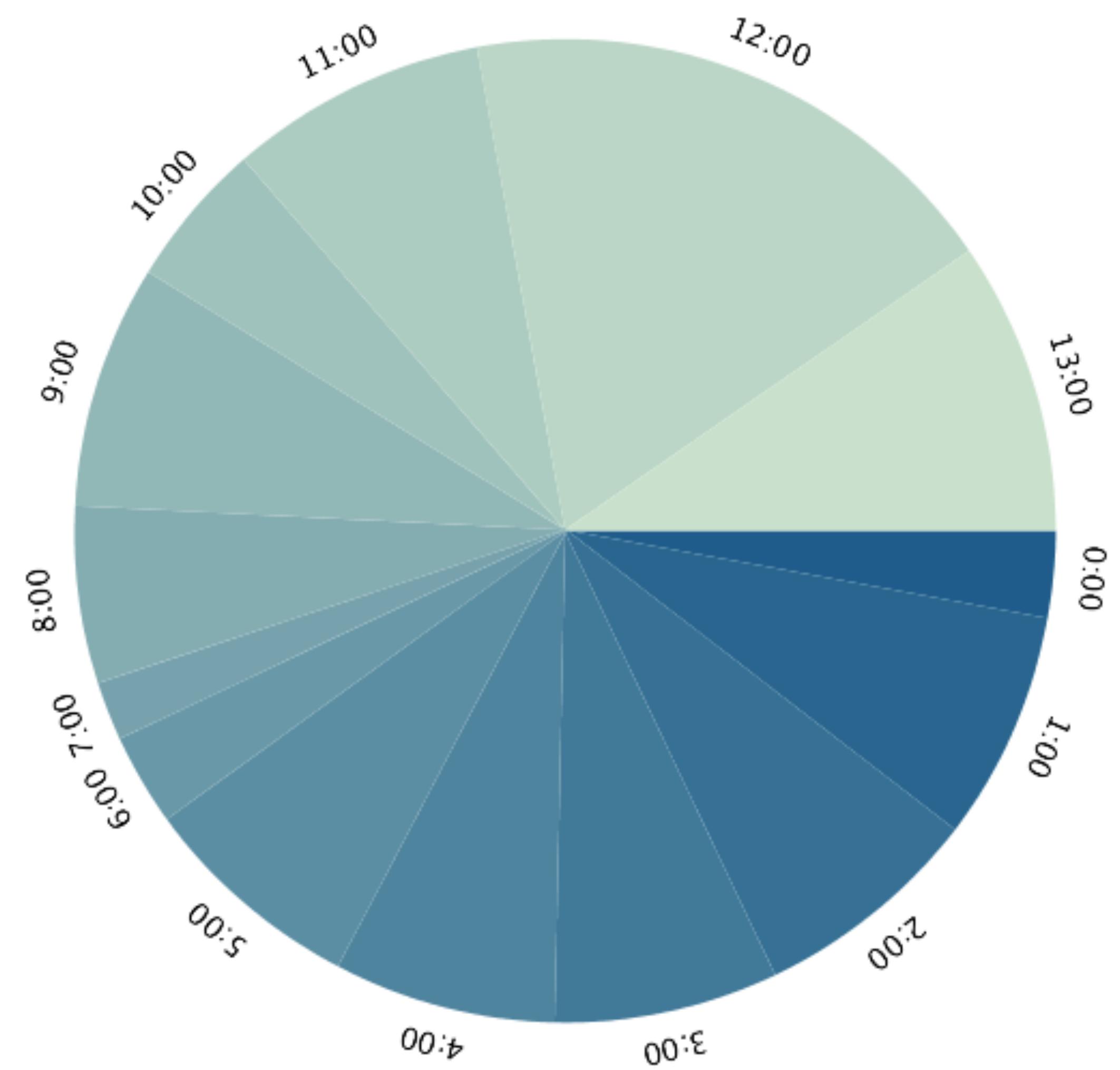


Framed
Unaligned



Unframed
Aligned

Use design elements to compensate!



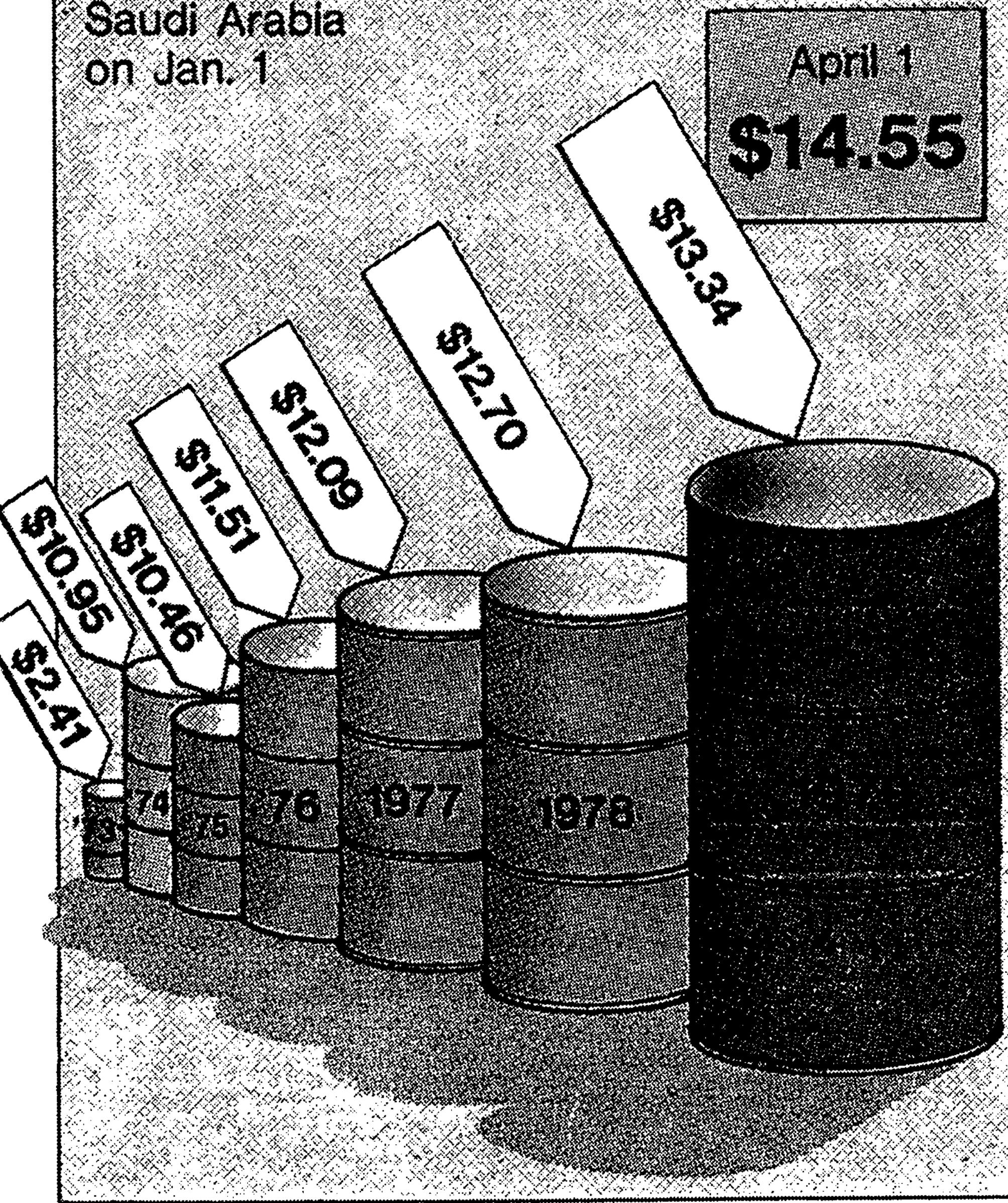
Angle

Volume

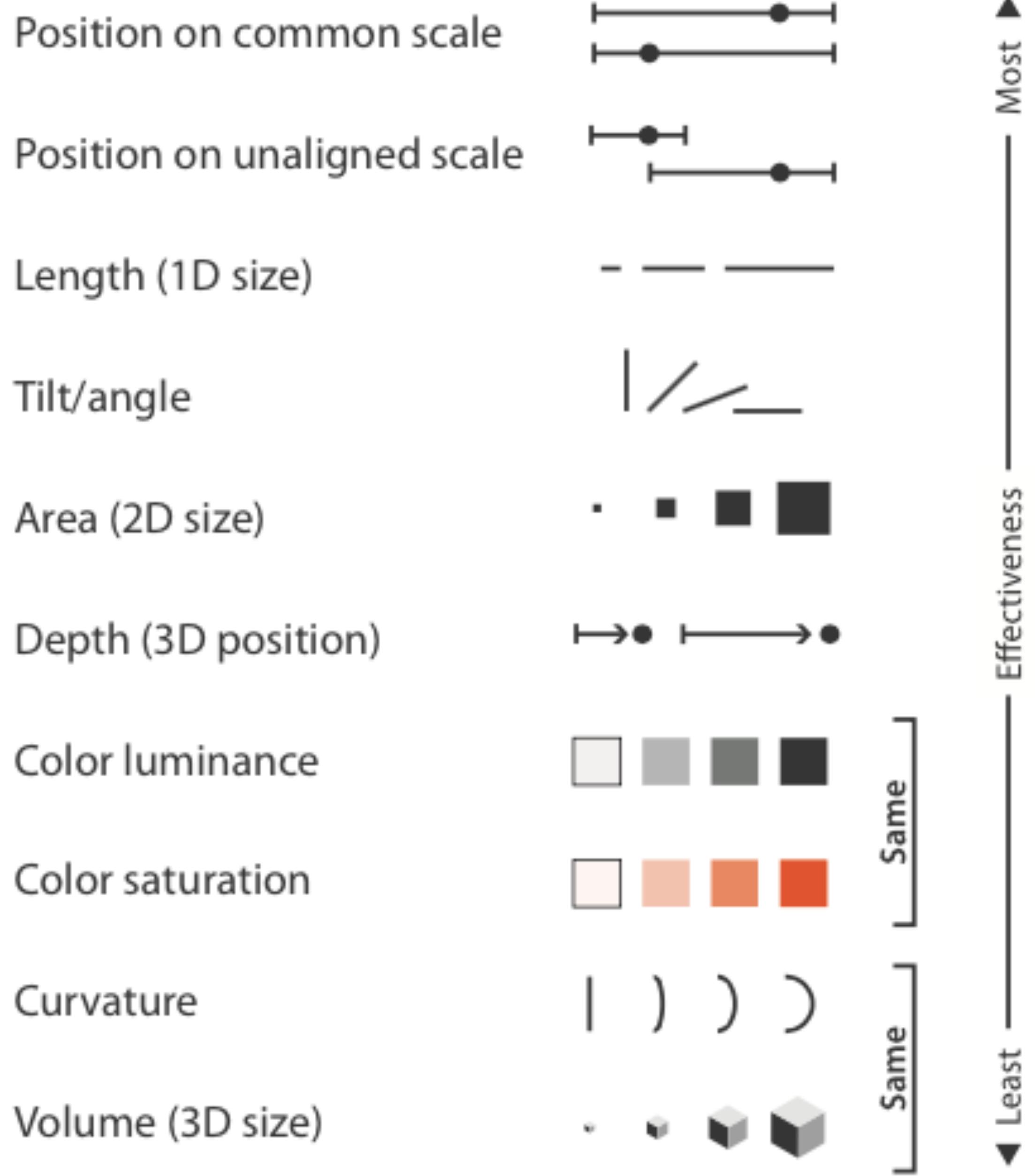
Accurate encoding does not ensure accurate perception!

IN THE BARREL...

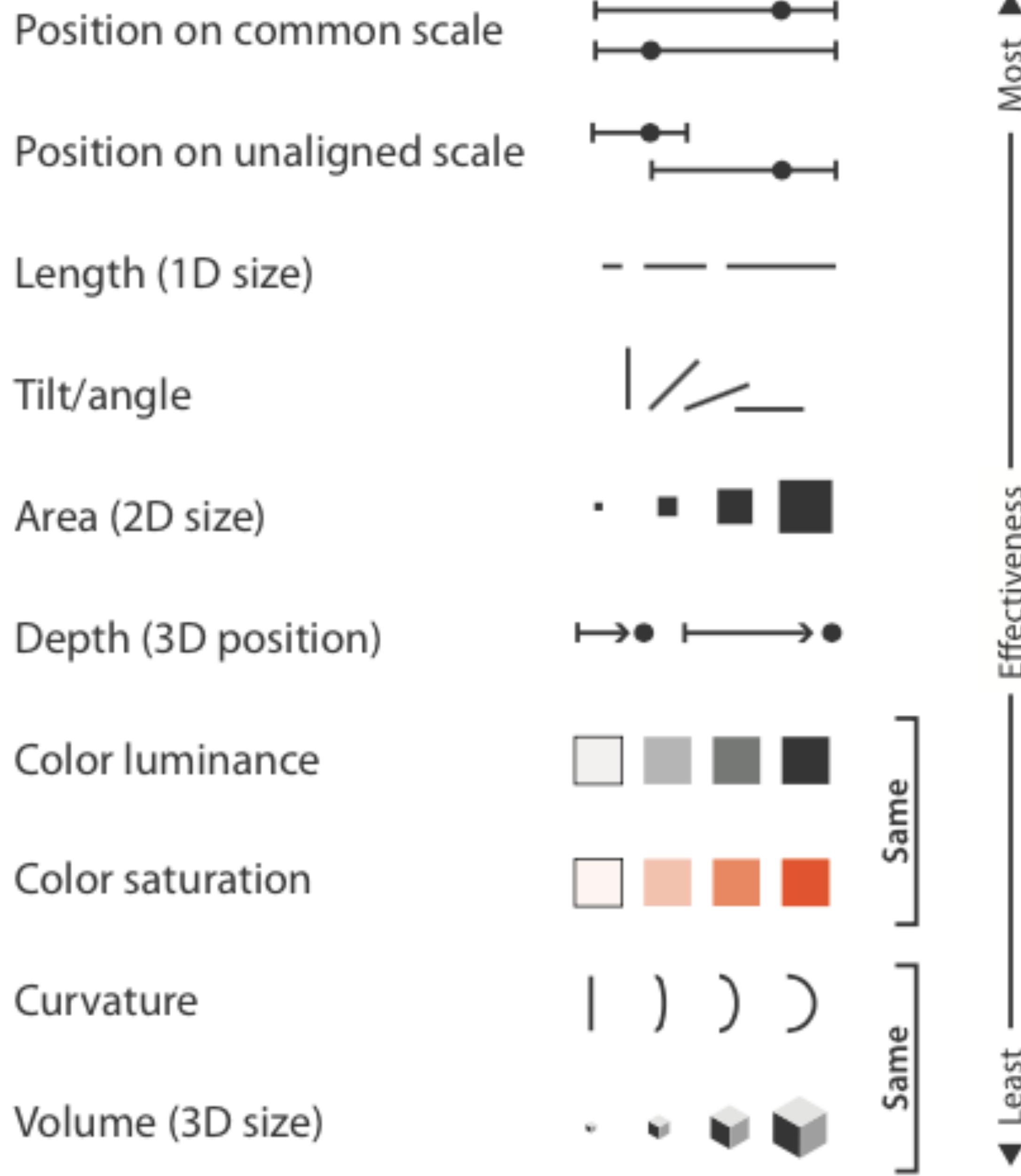
Price per bbl. of
light crude, leaving
Saudi Arabia
on Jan. 1



→ Magnitude Channels: Ordered Attributes



→ Magnitude Channels: Ordered Attributes



Luminance and Saturation—
really the same?

④ Magnitude Channels: Ordered Attributes

Position on common scale



Position on unaligned scale



Length (1D size)



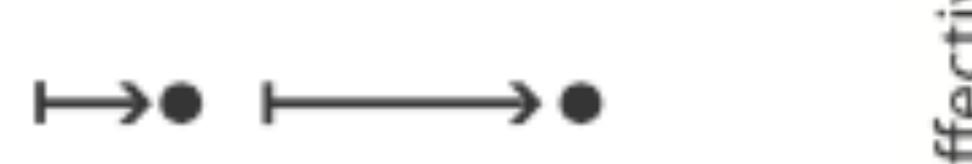
Tilt/angle



Area (2D size)



Depth (3D position)



Color luminance



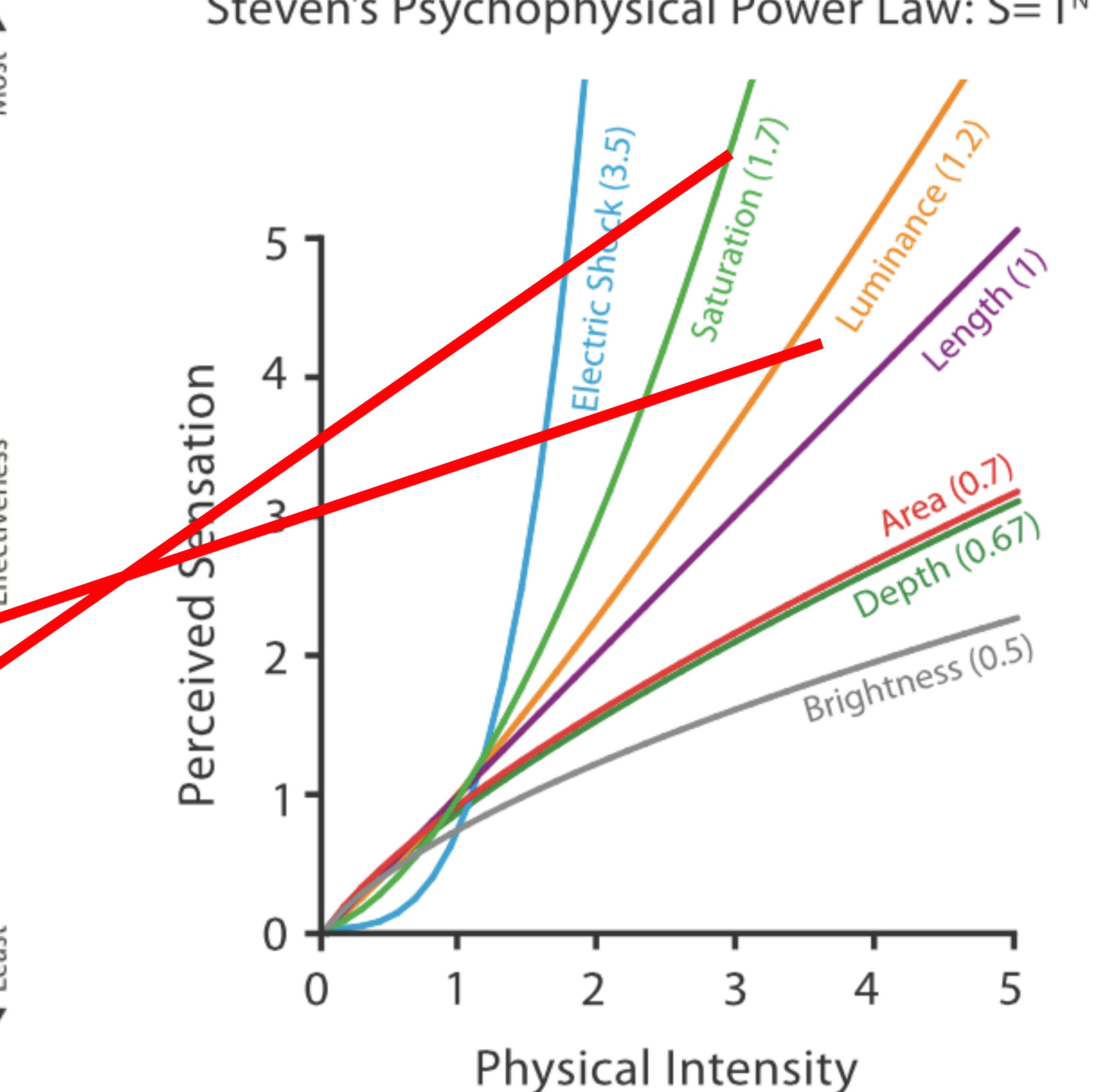
Color saturation



Curvature

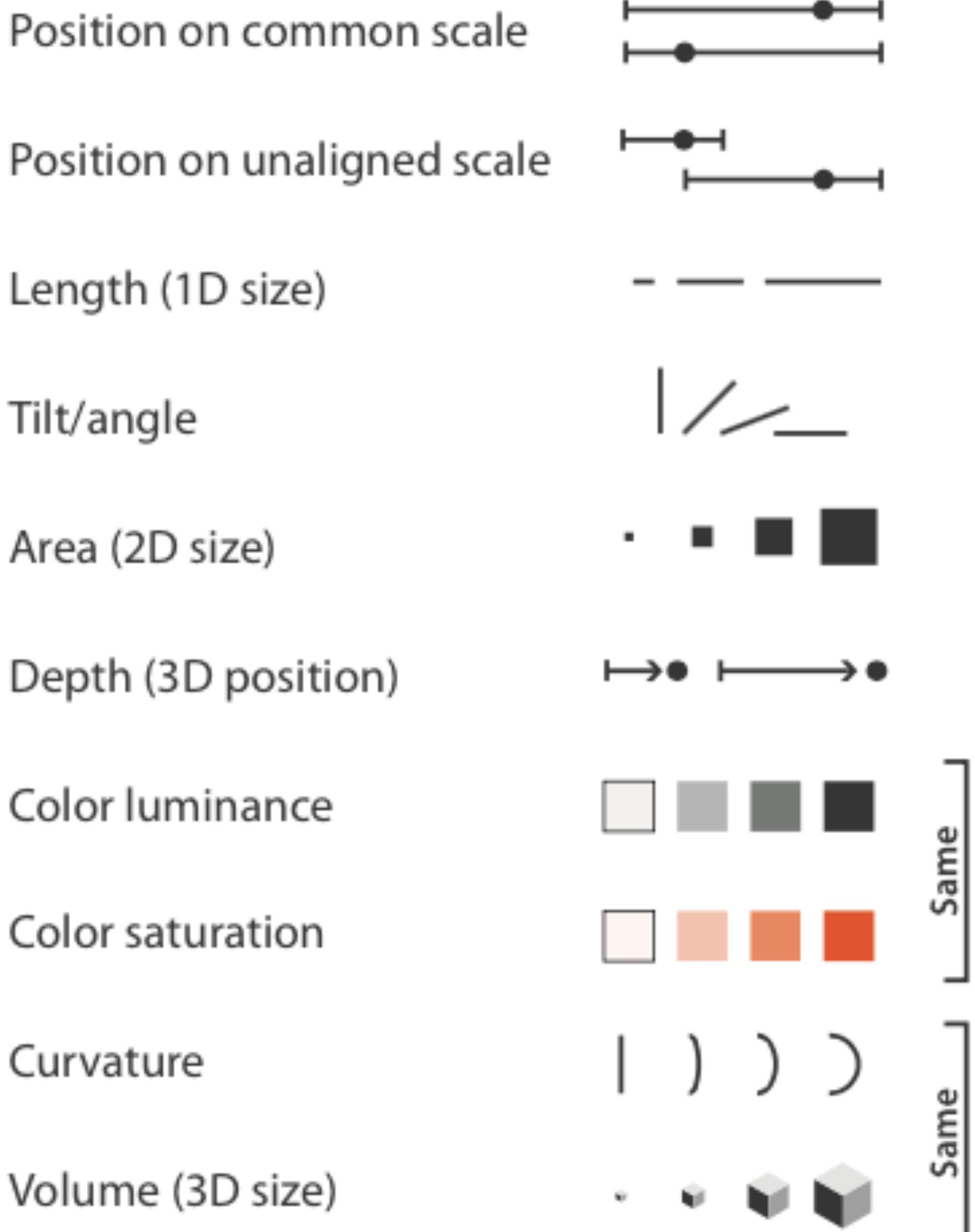


Volume (3D size)



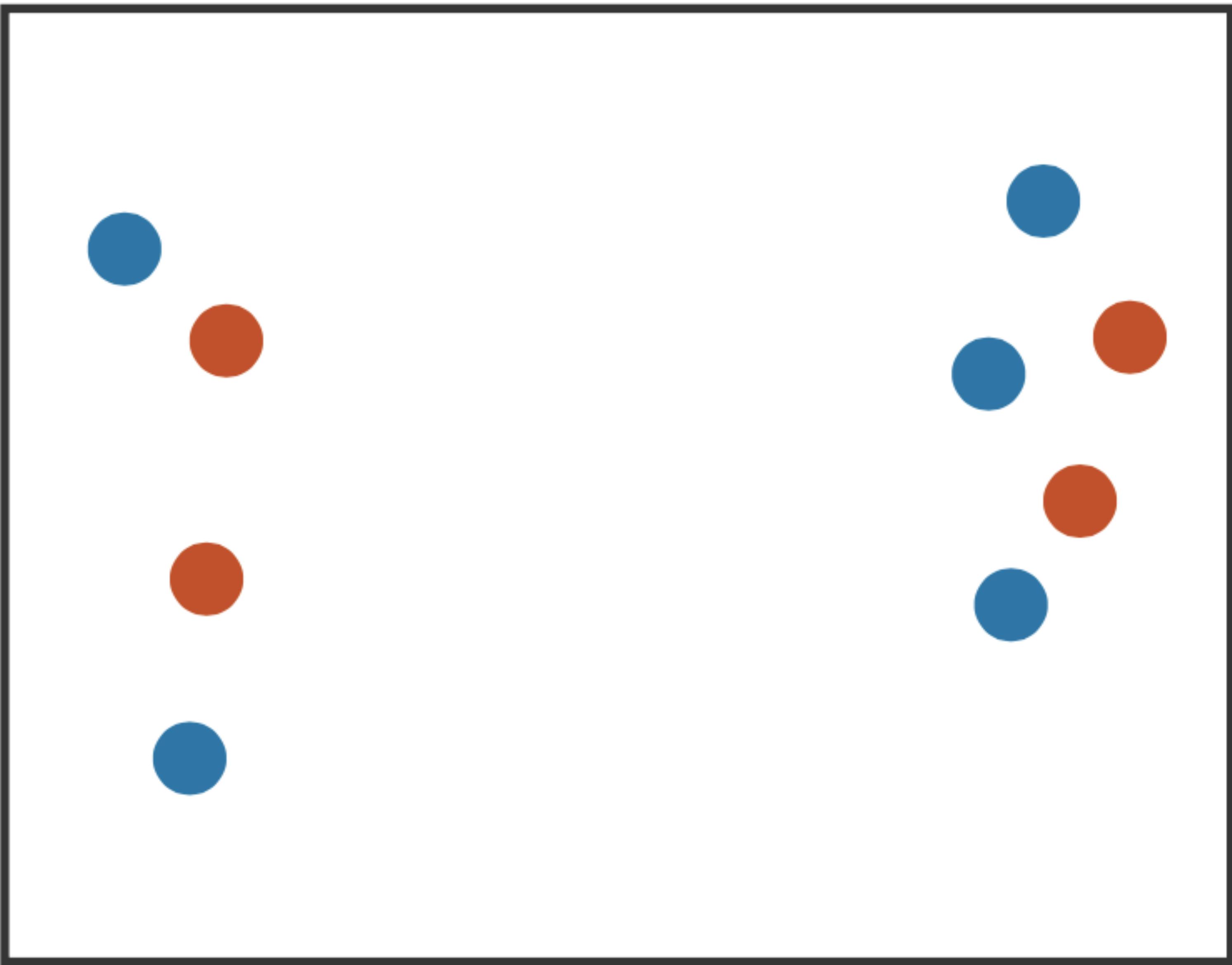
Identity

→ **Magnitude Channels: Ordered Attributes**



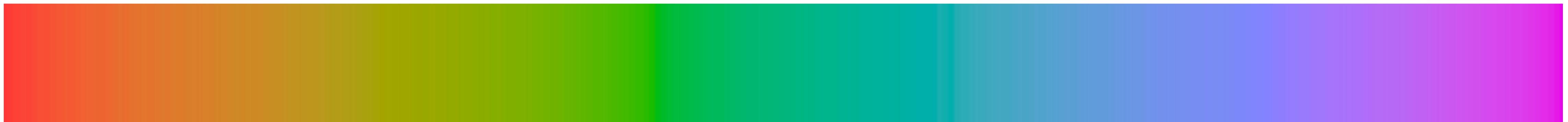
→ **Identity Channels: Categorical Attributes**



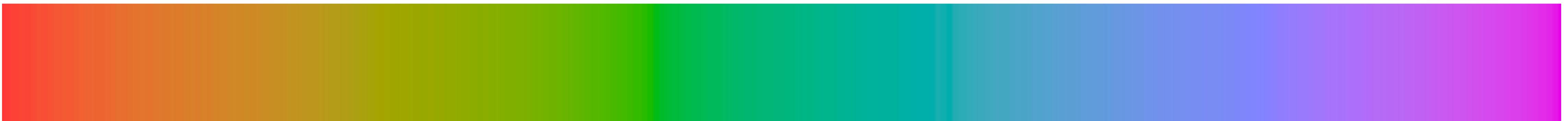


Spatial Region

Hue bad for magnitude:



Hue bad for magnitude:



Hue is great for identity:



Shape

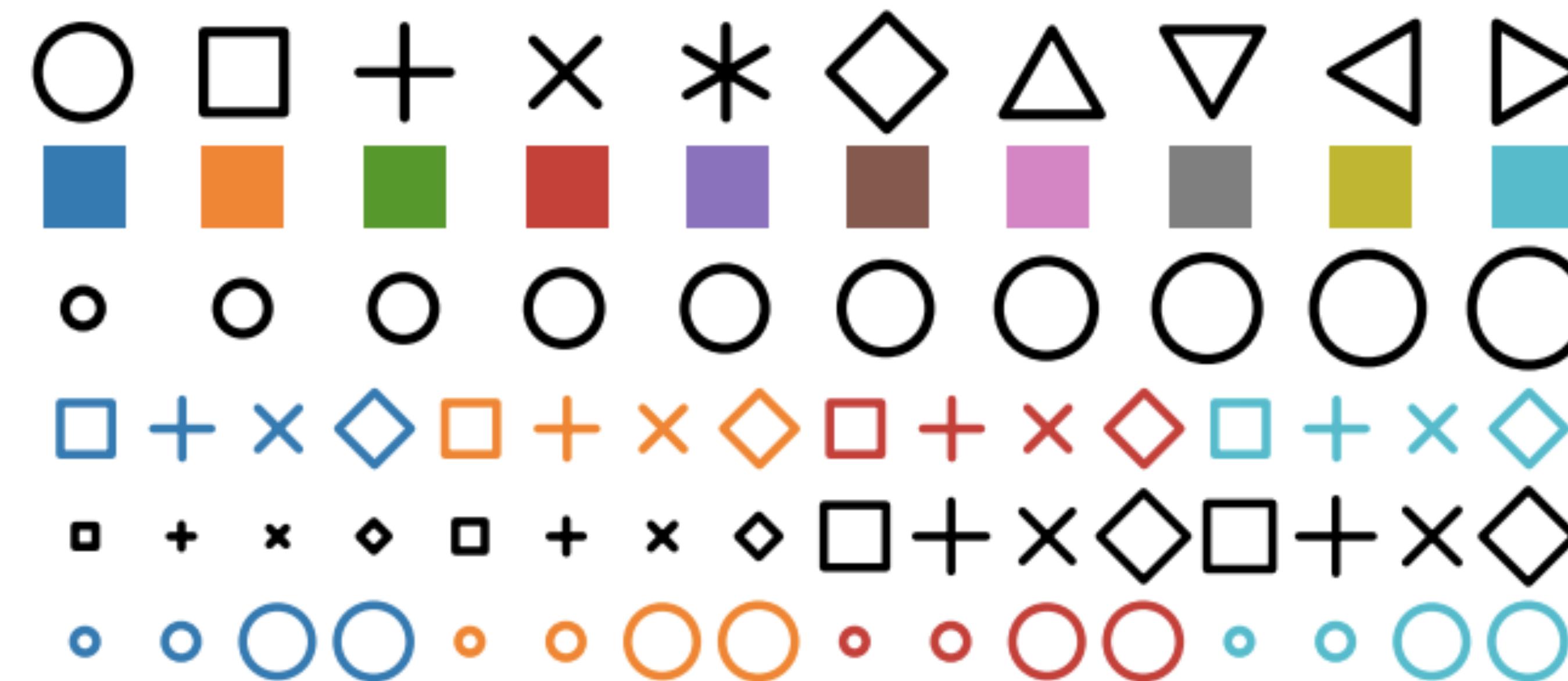


Fig. 2: Palettes of visual stimuli used in our experiments: shape, color, size, shape-color, shape-size, size-color.

Shape

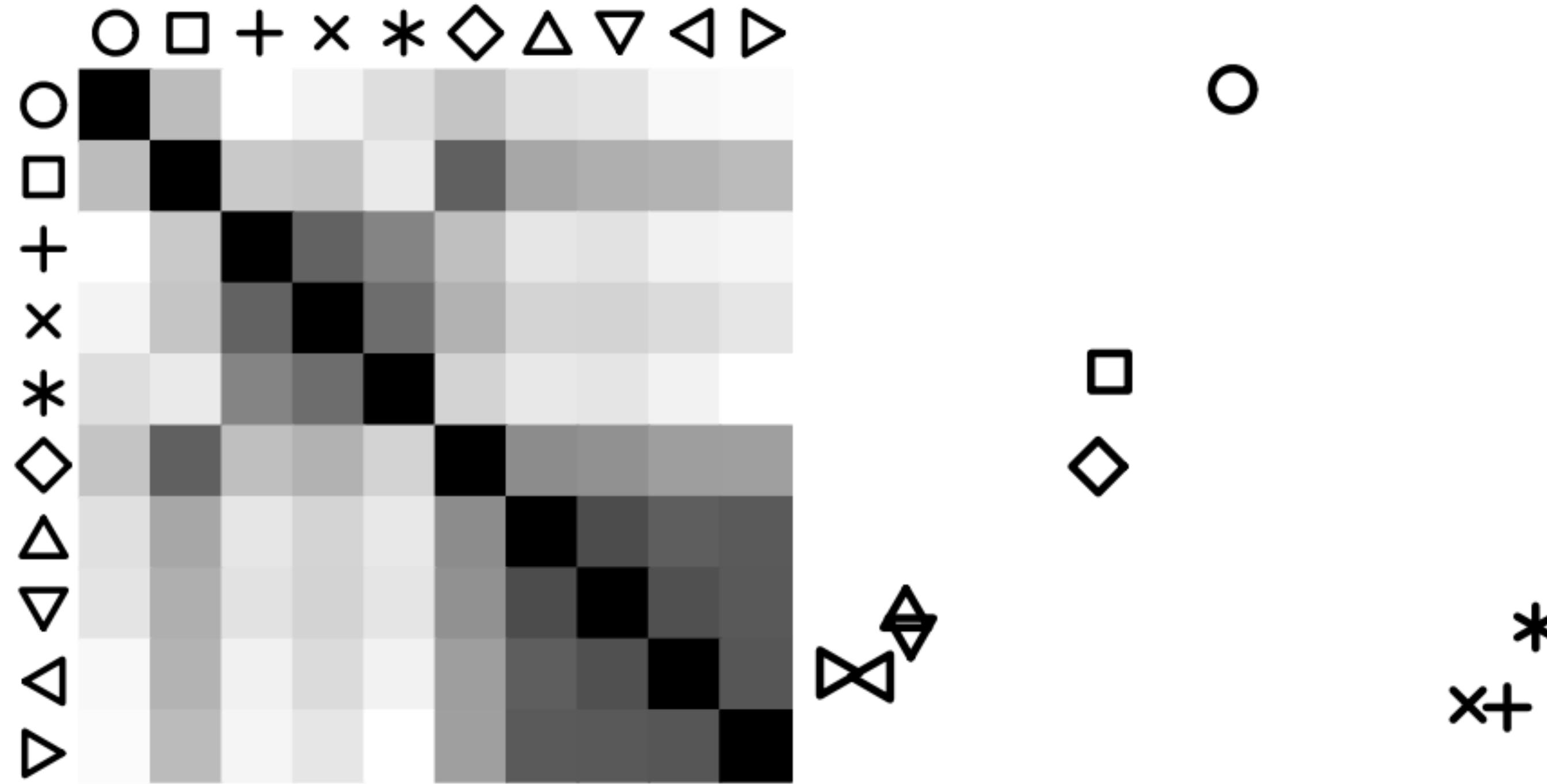
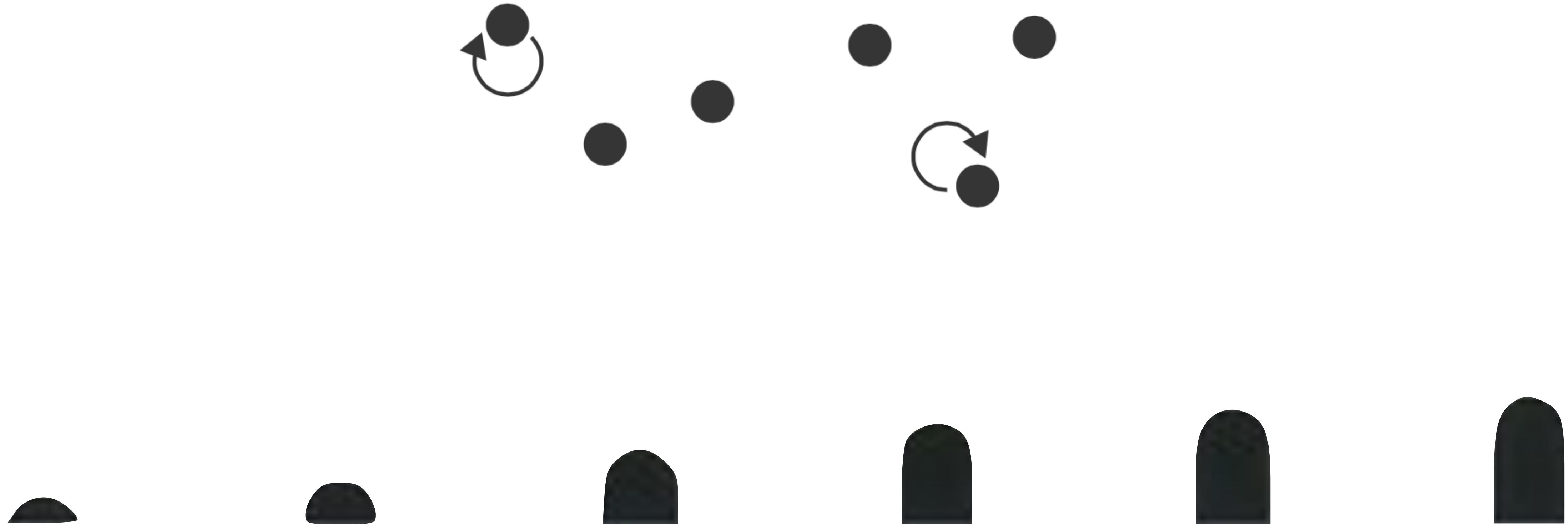


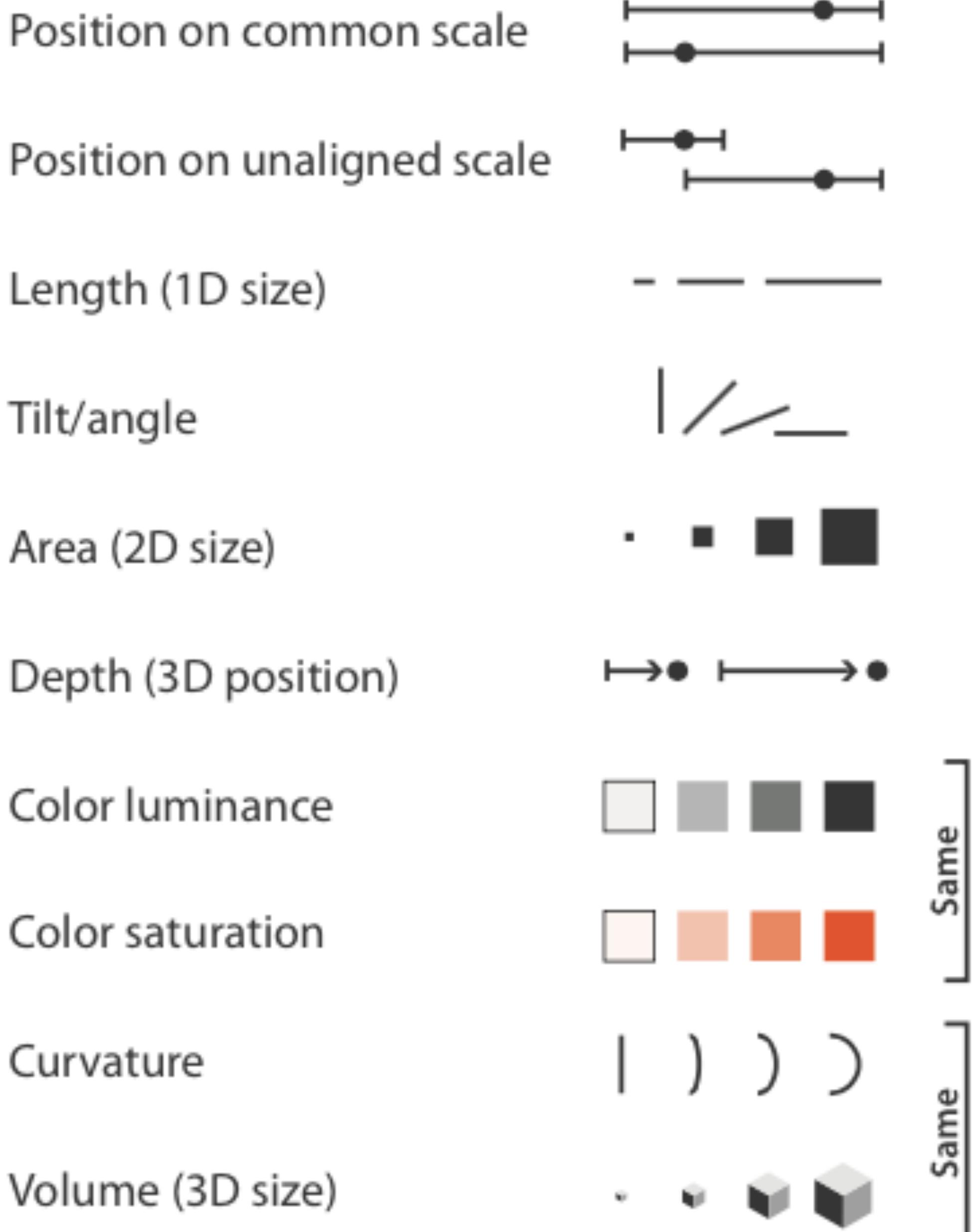
Fig. 1: (Left) A crowd-estimated perceptual kernel for a shape palette. The kernel was obtained using ordinal triplet matching. (Right) A two-dimensional projection of the palette shapes obtained via multidimensional scaling of the perceptual kernel.

Motion



(huge attention grabber, use with caution)

→ **Magnitude Channels: Ordered Attributes**



→ **Identity Channels: Categorical Attributes**

