Marks and Visual Channels

Basic building blocks of visualisation

Finite number

Understand their relevance

Marks

Marks

Basic graphical element in an image

Marks

Basic graphical element in an image

Geometric primitives

Marks

Basic graphical element in an image

Geometric primitives

Defined by dimension

Marks

Basic graphical element in an image

Geometric primitives

Defined by dimension

0 Dimension - point

Marks

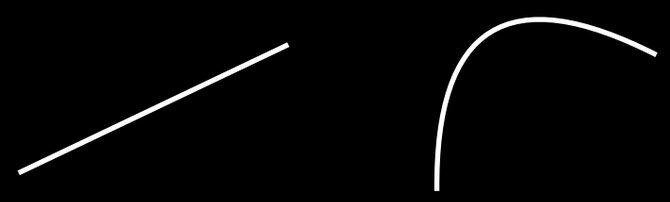
Basic graphical element in an image

Geometric primitives

Defined by dimension

0 Dimension - point

1 Dimension - line



Marks

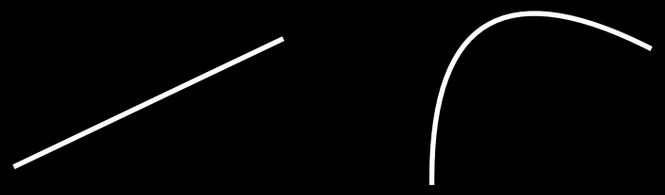
Basic graphical element in an image

Geometric primitives

Defined by dimension

0 Dimension - point

1 Dimension - line



2 Dimensions - area

Can also have three dimensional primitives…..

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But we avoid for later reasons

Visual channel

Visual channel

a way to control the appearance of marks, independent of the dimensionality of the geometric primitive.

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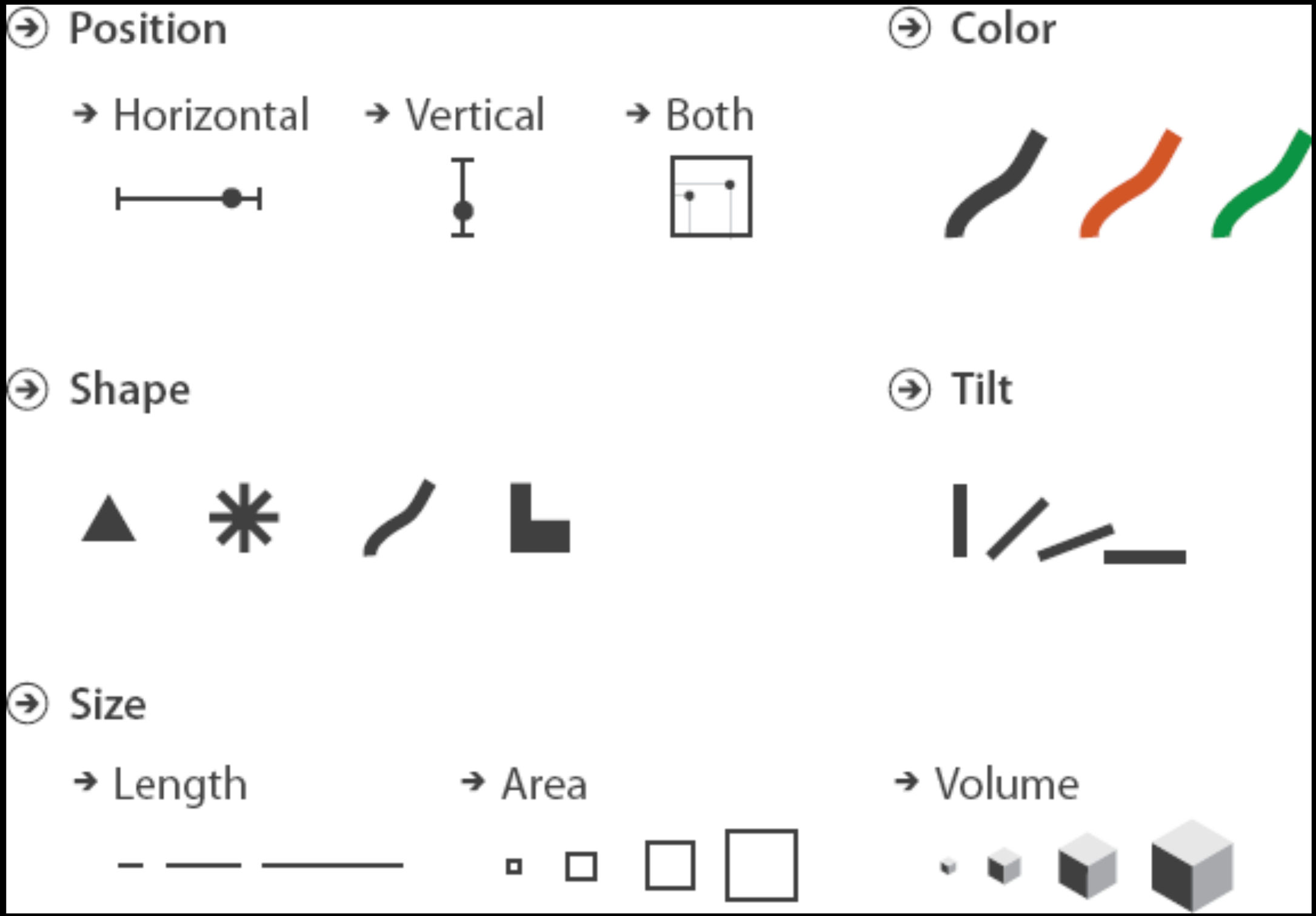
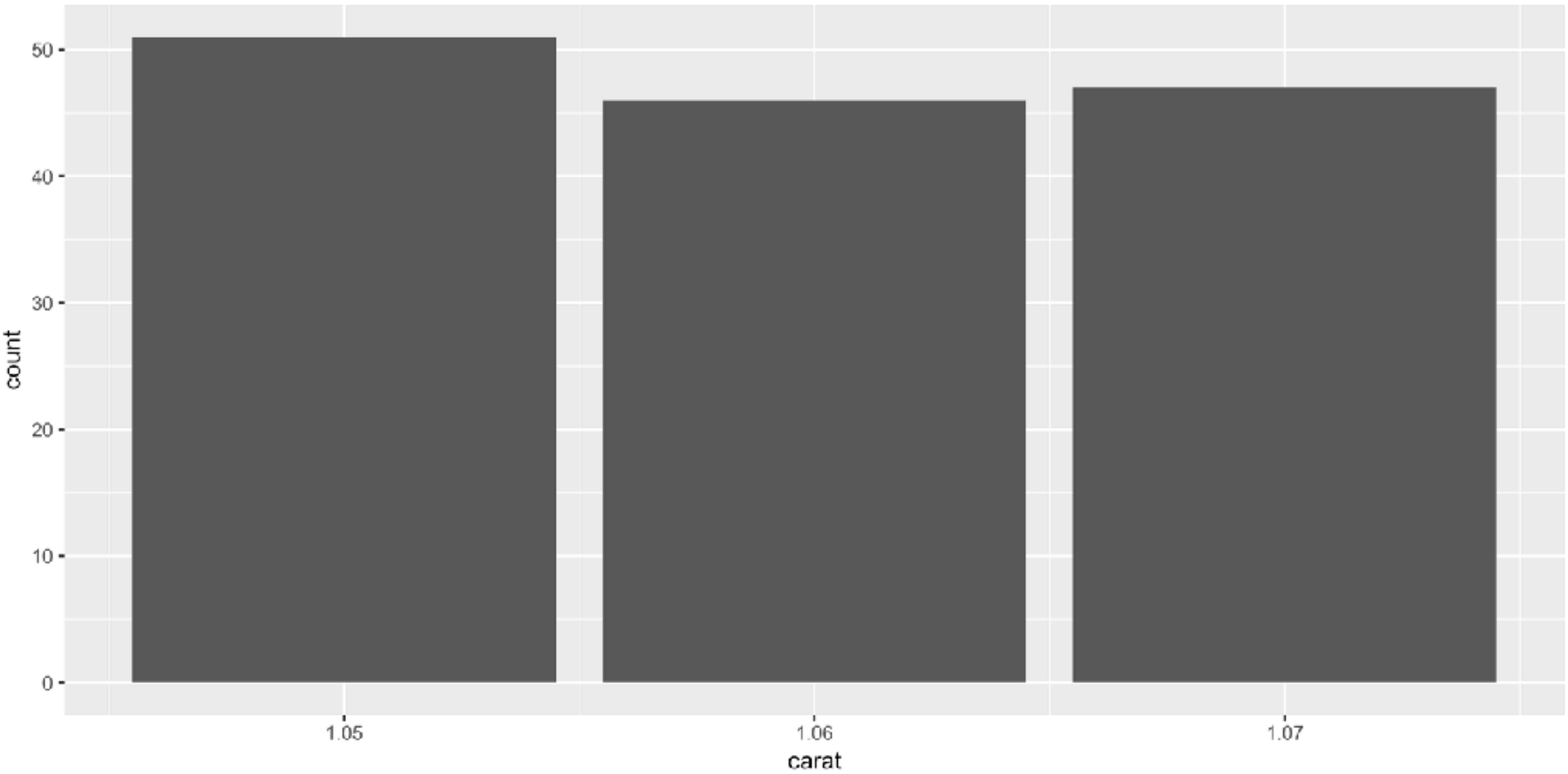
a way to control the appearance of marks, independent of the dimensionality of the geometric primitive.

Many synonyms for this term !

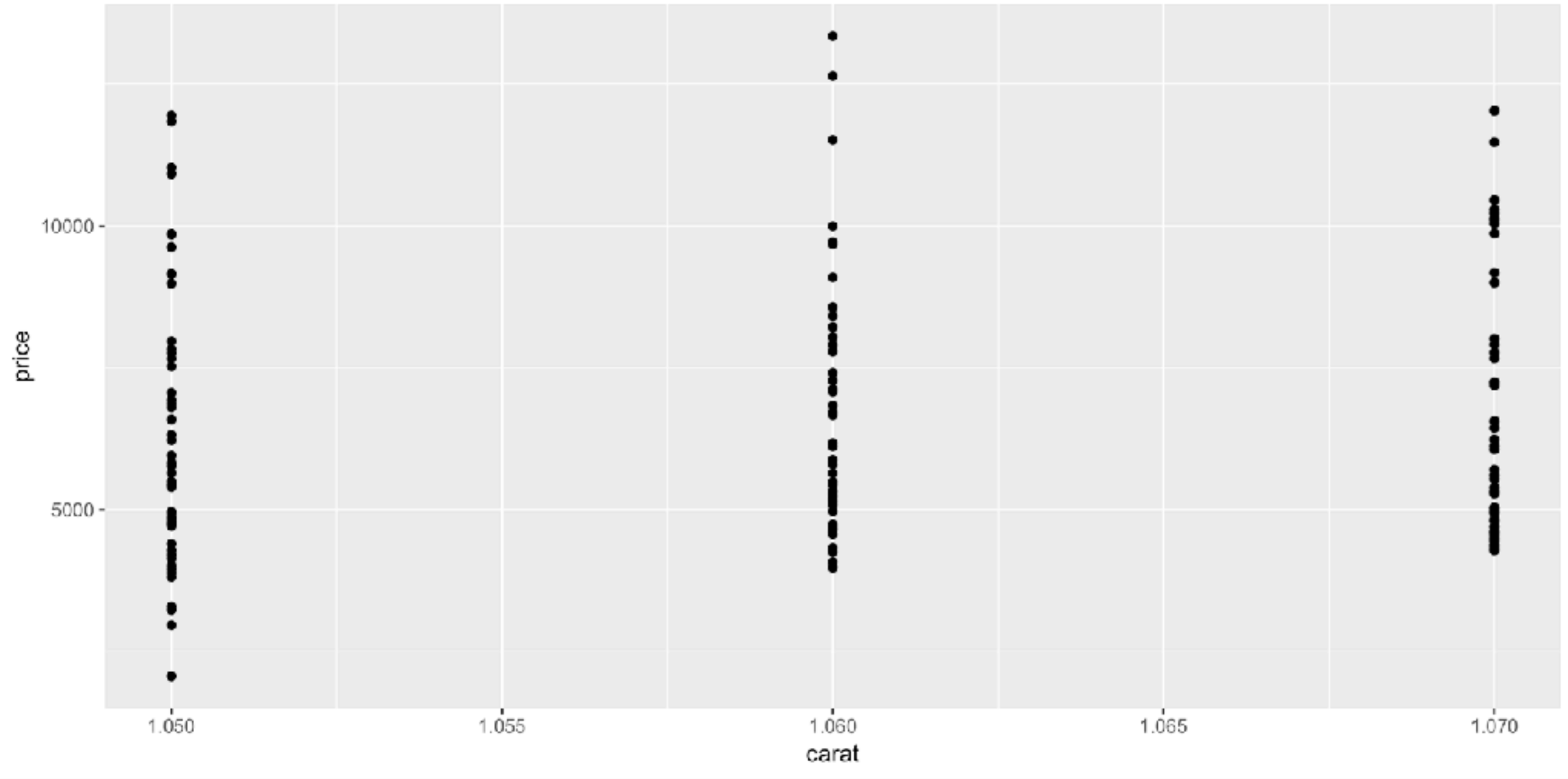
Examples of Visual Channels



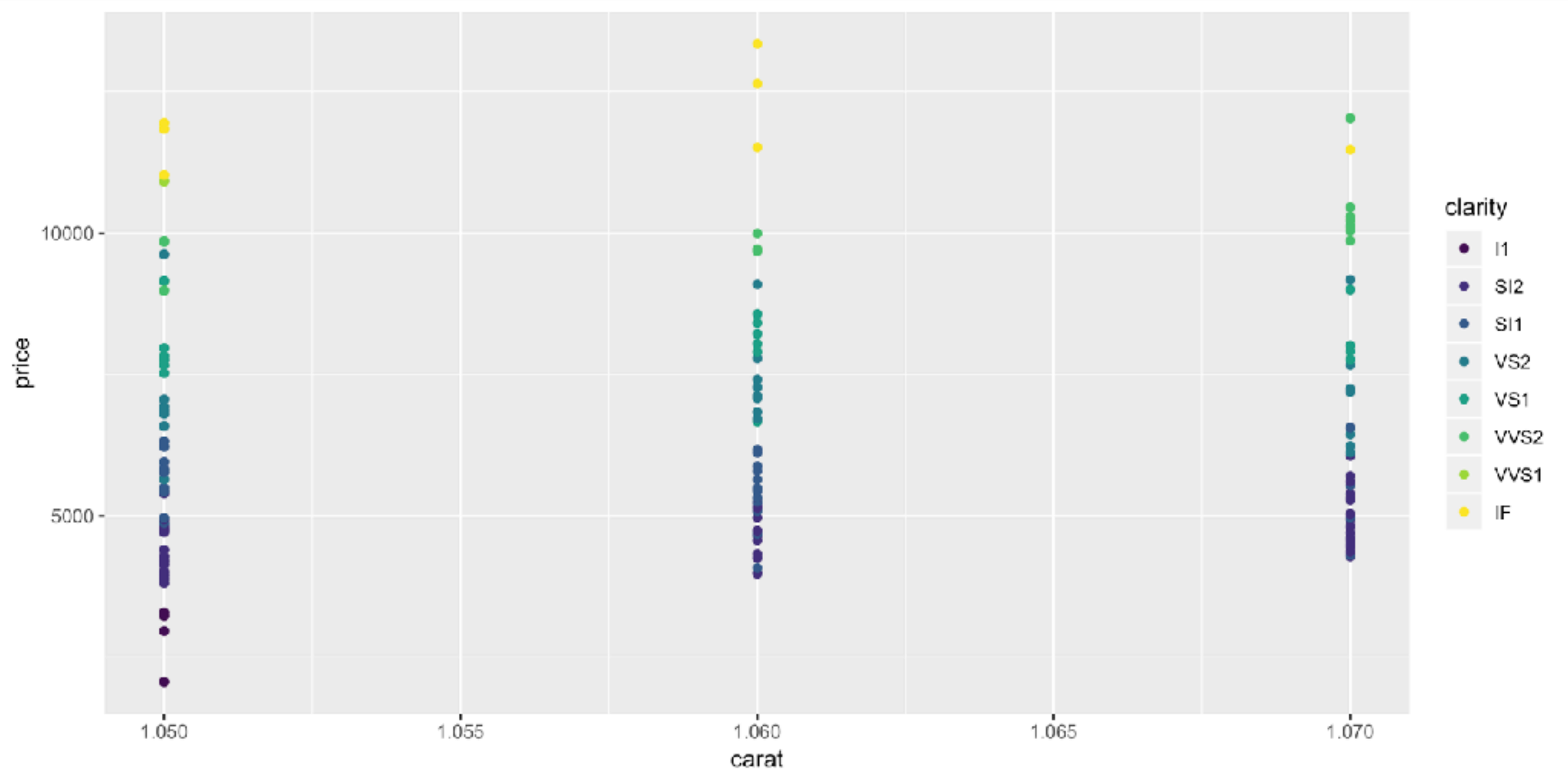
Bar plot of diamond prices in a small range of carats



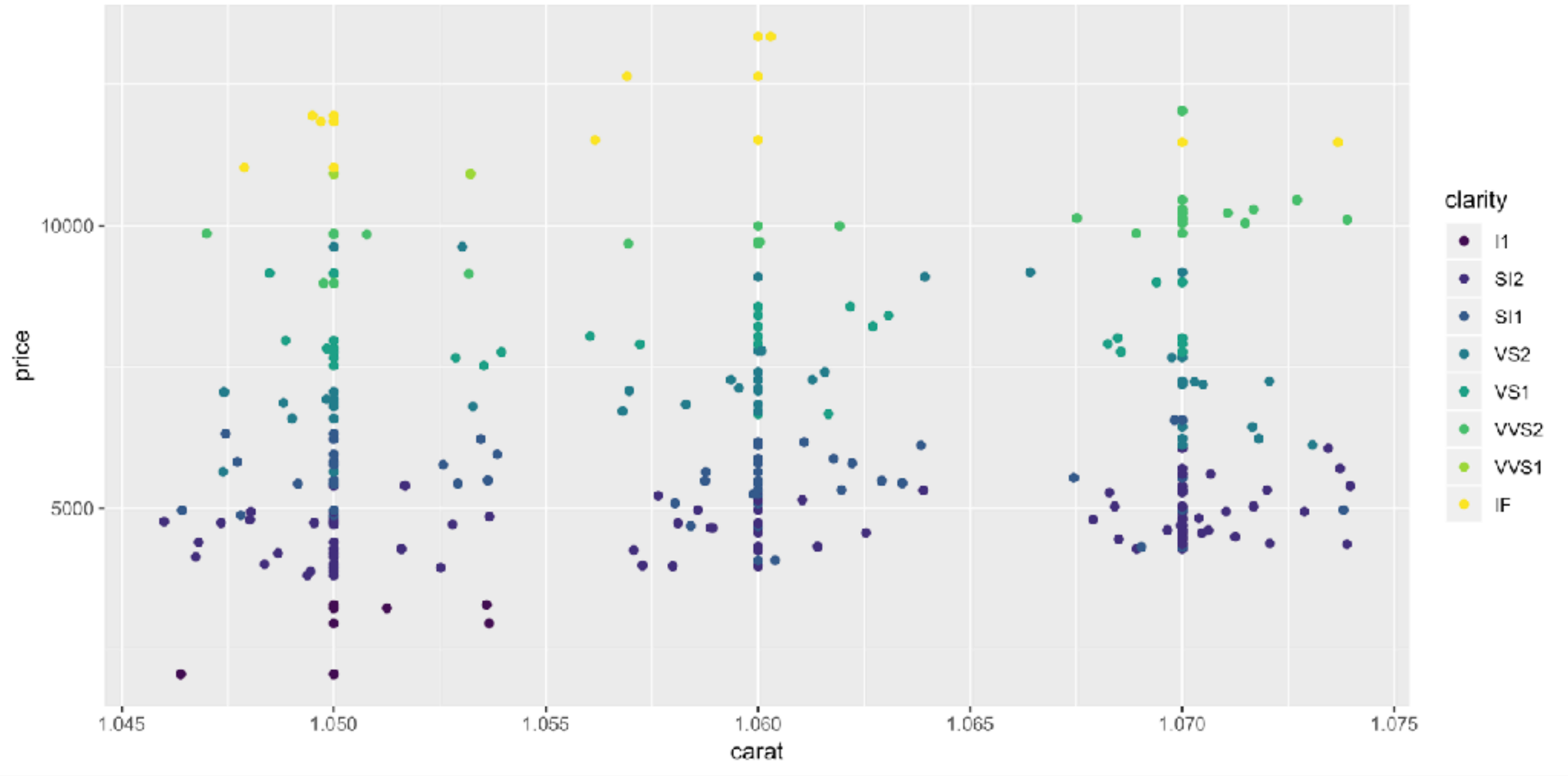
Scatter plot of diamond prices vs carat is same range



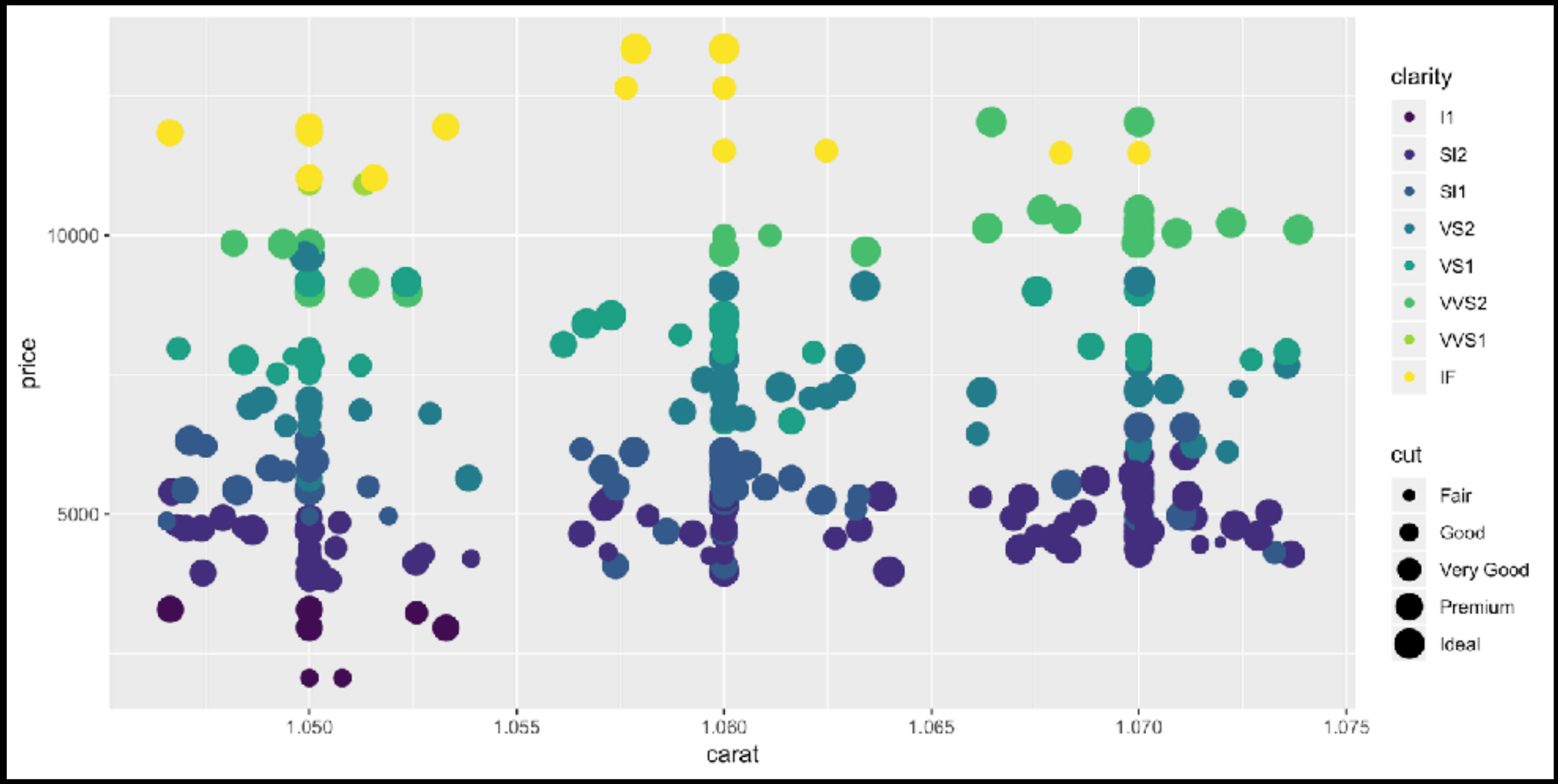
Scatter plot of same data now coloured according to clairity



Points “jittered” to see pattern



Size of points varied according to cut



Can also be redundant in the channels used to accentuate relationships.

e.g. using colour and size for clarity

Limitations

Cannot “mix and match” channels and marks entirely arbitrarily

Example - cannot adjust length of lines as already `taken’

Can’t adjust bar plot height in diamond data

Adjust width?

Channel types

Two kinds of sensory modalities

Identity channels - *what* something is; *where* it is

What-where (metathetic)

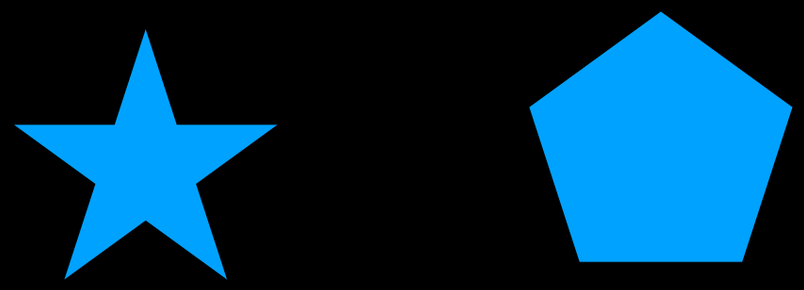
Magnitude channels - *how much* there is

How much (prothetic)

Examples

Identity channels

Shape



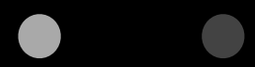
Colour hue

Can tell where the mark is on e.g. a grid, geometry or map

Magnitude channels

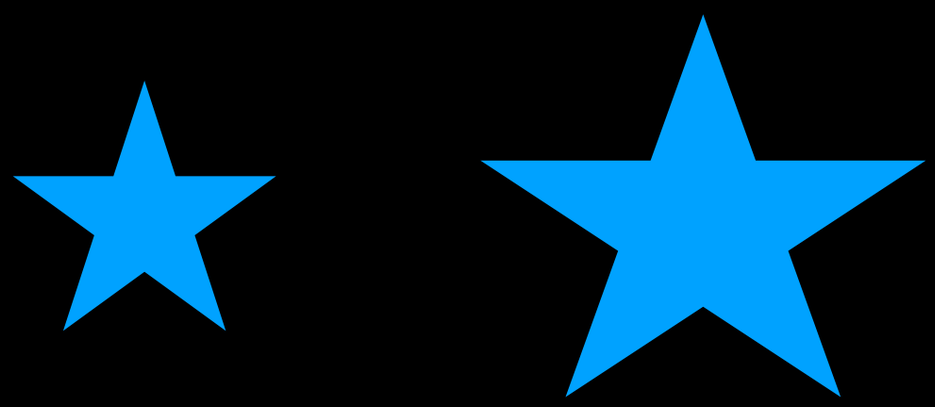
Two lines - which is longer?

Brightness



Tilt

Area



Channels are not all equally useful.

Want channels to be

Expressive

Effective

Expressiveness principle

the visual encoding should express all of, and only, the information in the dataset attributes

Ordered data should be seen in a way we perceive as ordered

Unordered data should *not* be seen in a way we perceive as ordered

Example - Not Expressive

Representing a set of heights with a set of symbols

< 1.0 m - Use a Star

> 1.0 m and < 2.0 m - Use a plus

Effectiveness principle

The most important attributes should be encoded with the most *noticeable* channels.

Decreasingly important attributes are matched with less *noticeable* channels.

Noticeable ?

Our brains do not notice different channels to the same level

Channels: Expressiveness Types and Effectiveness Ranks

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

Aspects of effectiveness

Accuracy

How close is human perceptual judgment to some objective measure?

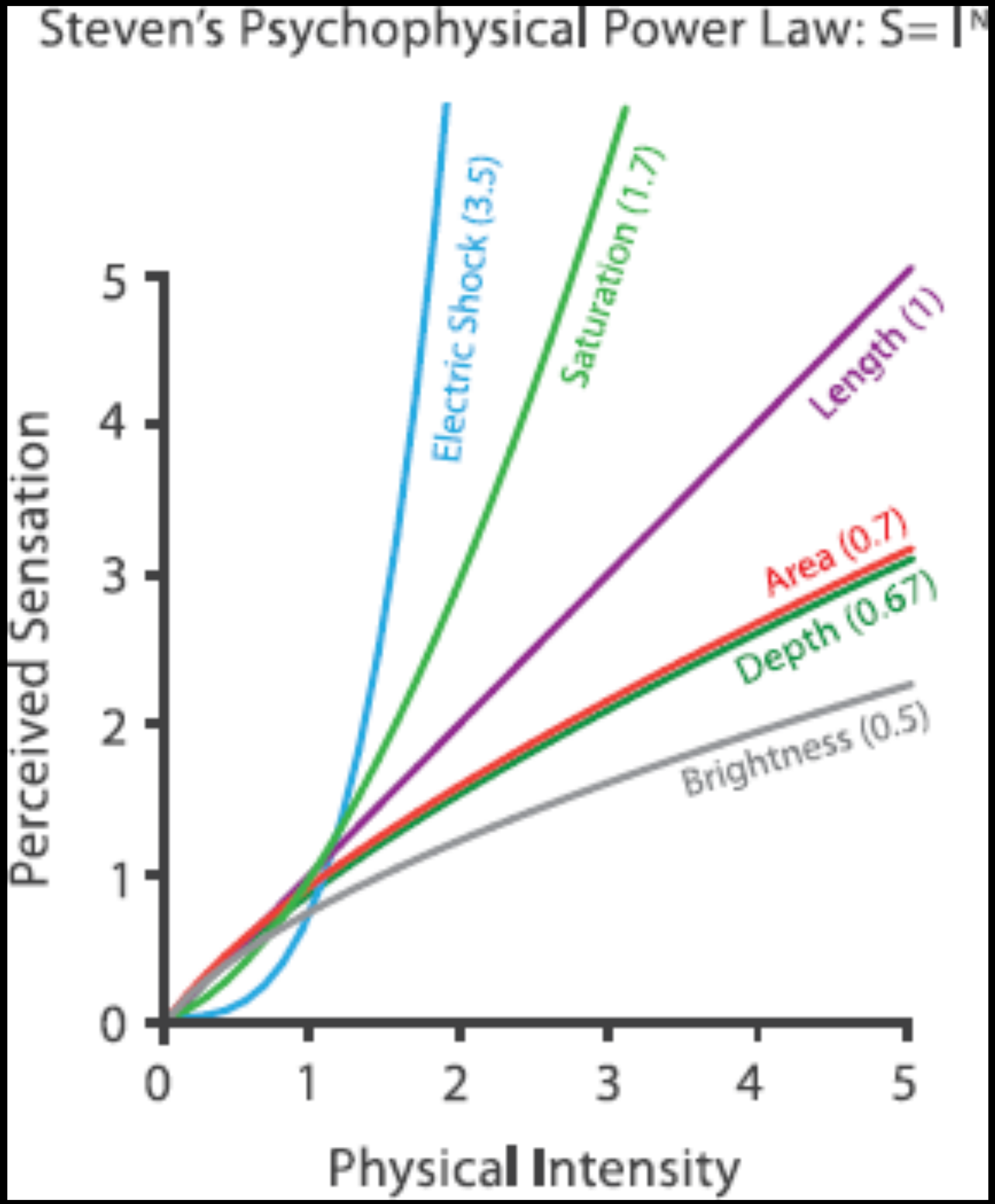
Relatively simple Mathematical model

Steven’s Psychophysical Power Law

$$S \propto I^n$$

S - Perceived Sensation

I - Physical Intensity


Steven's Psychophysical Power Law: S= I^N
Perceived Sensation
Physical Intensity
0
1
2
3
4
5
Electric Shock (3.5)
Saturation (1.7)
Length (1)
Area (0.7)
Depth (0.67)
Brightness (0.5)

Nobody’s ever figured out to use Electric Shock in Visualisation

Well almost nobody

Heer and Bostock, Crowd-sourced effort 2010

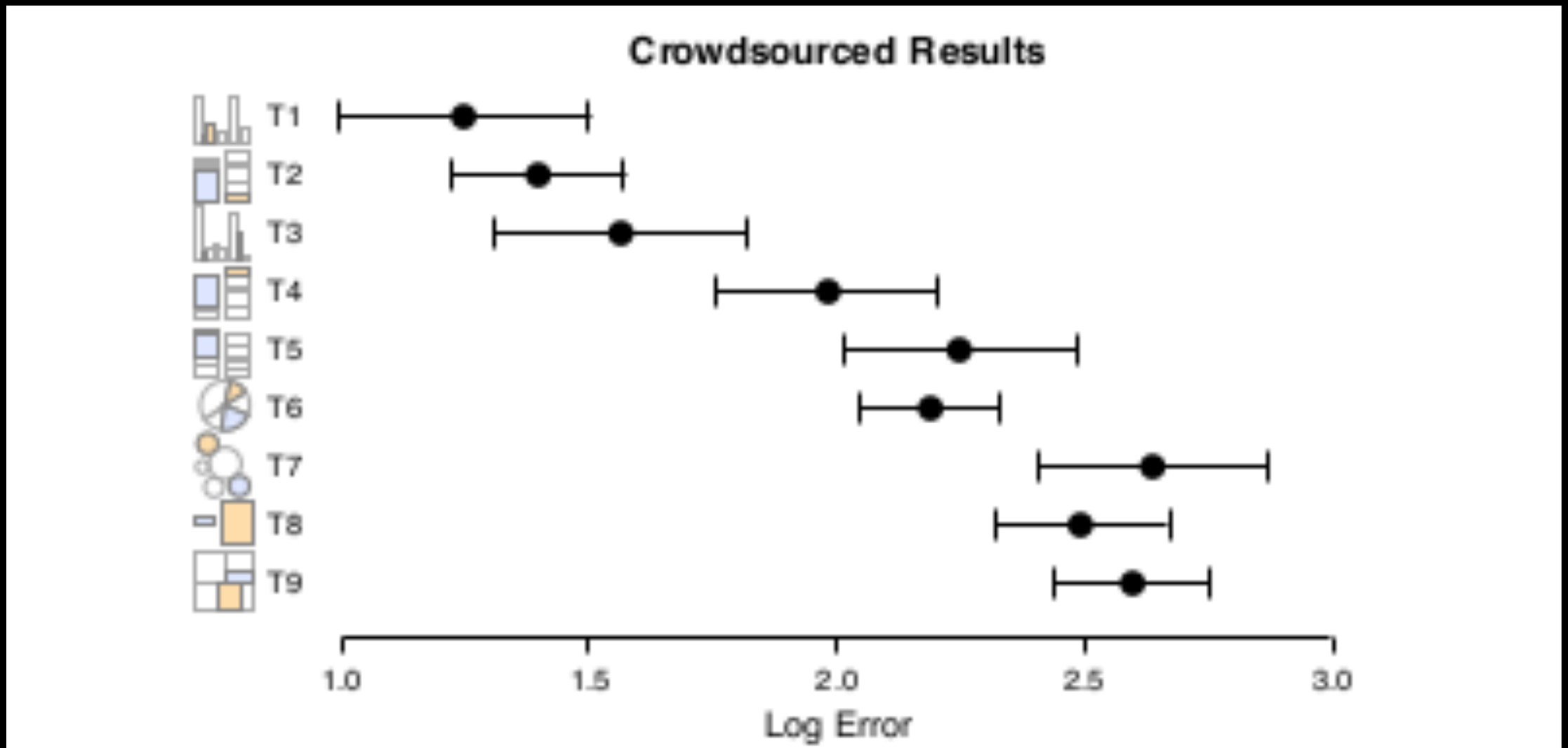


Figure 4: Proportional judgment results (Exp. 1A & B). Top: Cleveland & McGill's [7] lab study. Bottom: MTurk studies. Error bars indicate 95% confidence intervals.

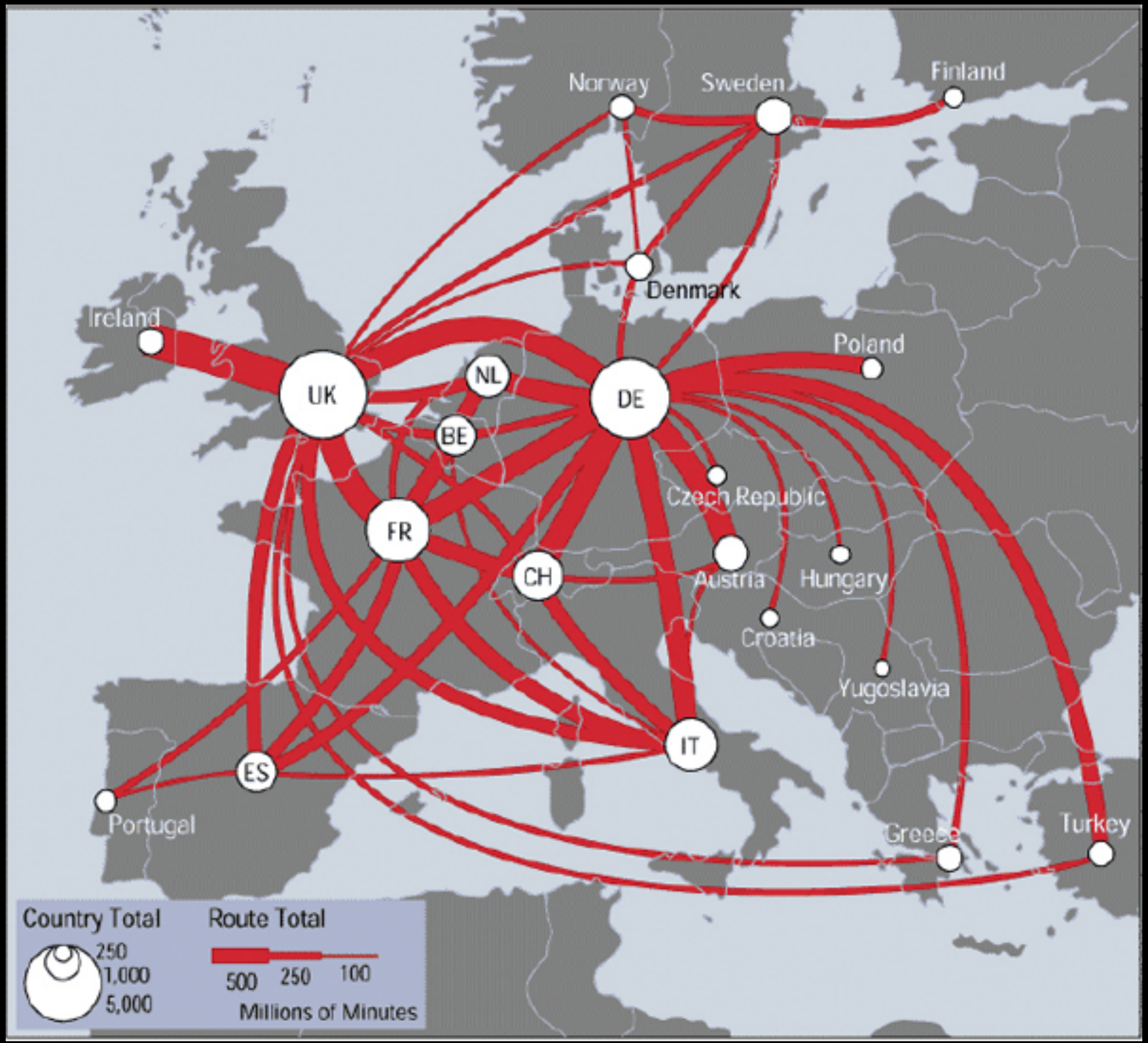
Discriminability

How perceptible are differences between items to a human?

Example width of a line

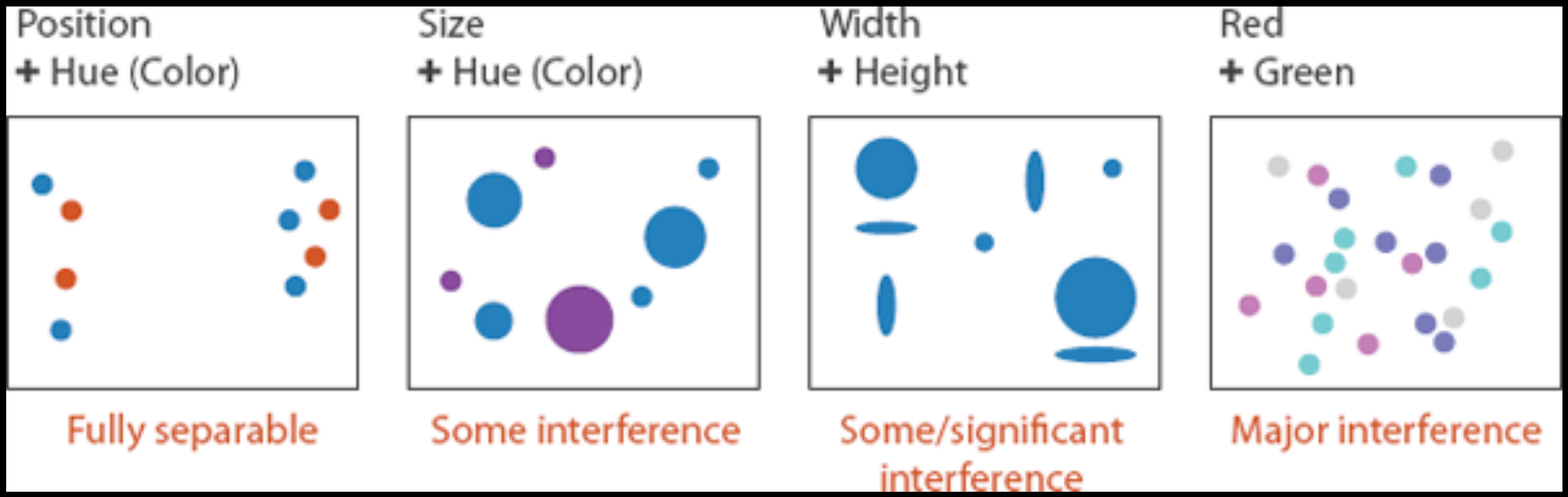
Good for three to four ordered values

Not for hundreds!


Norway
Sweden
Finland
Denmark
Ireland
Poland
UK
NL
DE
BE
Czech Republic
FR
CH
Austria
Hungary
Croatia
Yugoslavia
IT
ES
Portugal
Greece
Turkey
Country Total
250
1,000
5,000
Route Total
500
250
100
Millions of Minutes

Separability

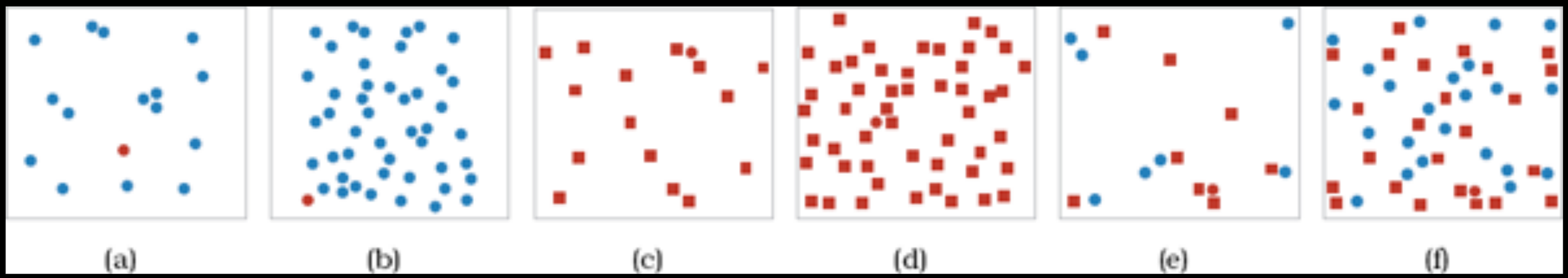
Channels can interact with each other



Popout

How well a distinct item stands out from many others immediately.

Colour much better than shape.



Weber’s Law (1834)

Human perception based on relative, not absolute, changes

Example (taken from https://bit.ly/2E0HgNa)

Suppose you are lifting weights and you are blindfolded

Initially holding 2 Kg

How much more needs to be added before you notice a change?

Suppose you only notice a change after extra 0.2 Kg added.

What if you are now holding 5 Kg - what is smallest noticeable change?

Find only notice a change after extra 0.5 Kg added.

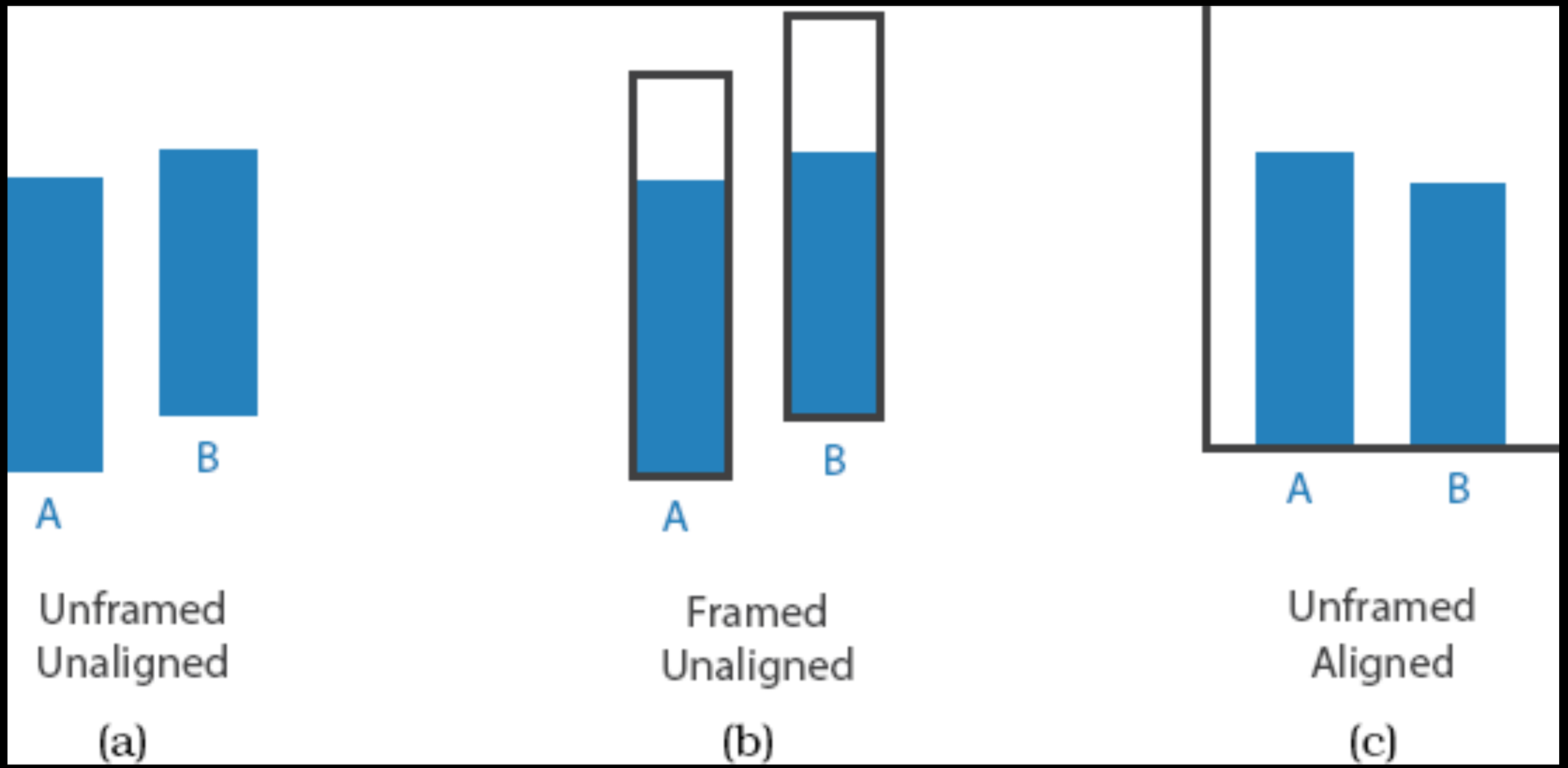
$$\frac{\text{Smallest Noticeable Change}}{\text{Intensity}} = \text{Constant}$$

$$\frac{\text{Smallest Noticeable Change}}{\text{Intensity}} = \text{Constant}$$

Weber's Law

Holds also for channels in visualisation

Upshot - need to think carefully about how to relative comparisons



Unframed
Unaligned

(a)

Framed
Unaligned

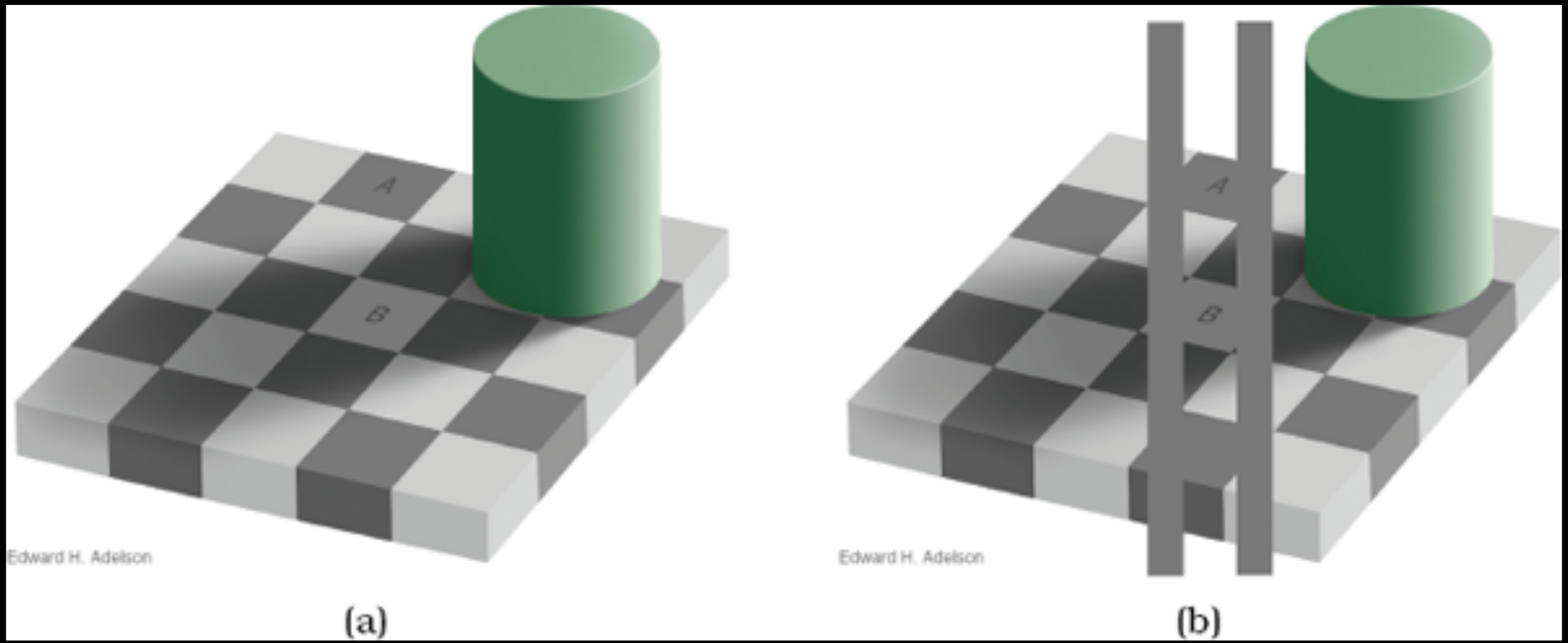
(b)

Unframed
Aligned

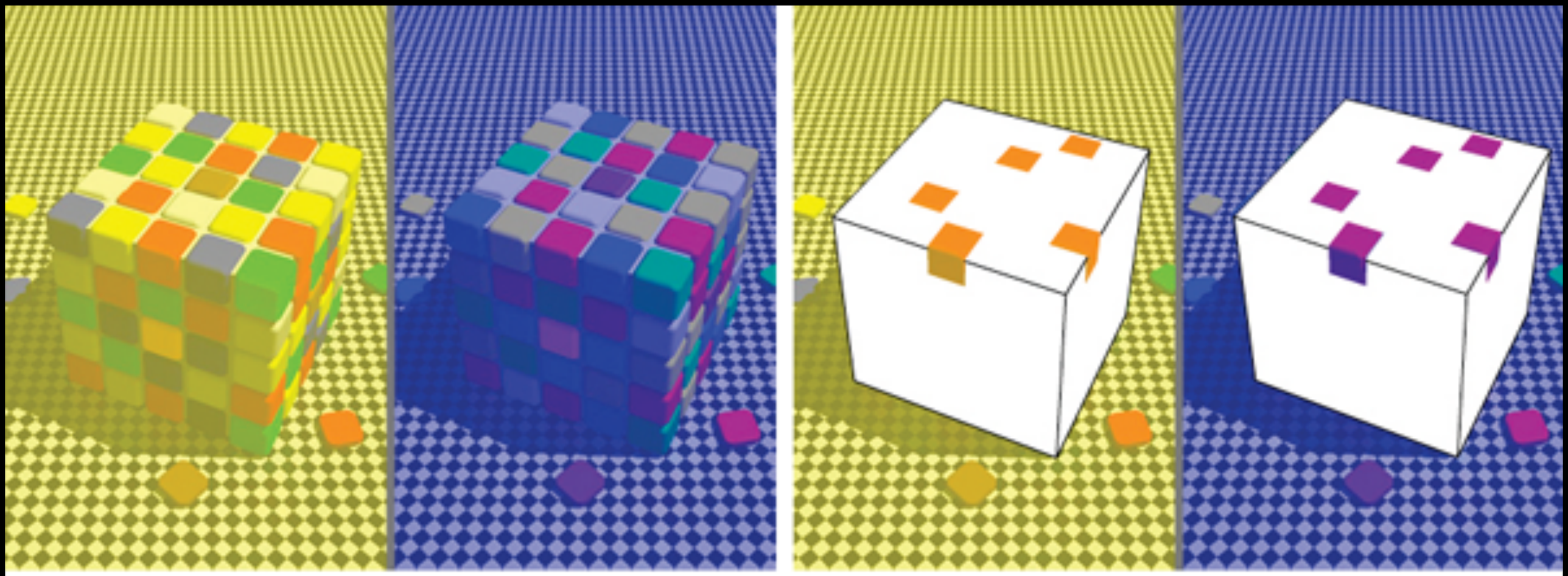
(c)

Which is longer A or B?

Situation even harder with colour and contrast….



(a) (b)



(a) (b)