

# Perception & Color

**Designing charts for the human visual system — then learning how to *read* charts defensibly.**

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# Today's Plan

01 · PERCEPTION

## How people see charts

Preattentive cues, grouping, and limits.

02 · COLOR

## Mapping colors to data

Palette types + accessibility basics.

03 · CHART READING

## Spot misleading encodings

Pitfalls that break trust.

04 · PRACTICE

## Audit + redesign

A workflow you can repeat.

# Learning Outcomes

## PERCEPTION

**Choose channels that humans compare well**

Position and length beat area and angle.

## COLOR

**Match palette type to data type**

Qualitative vs sequential vs diverging.

## ACCESSIBILITY

**Design beyond “color only”**

Contrast + redundancy + clear labeling.

## CHART READING

**Audit charts for misleading choices**

Axes, baselines, scales, and aggregation.

PART 1 · PERCEPTION

# Perception is the interface

The chart is not the message. The viewer's *perception* is.

# The Visualization Pipeline (Where Errors Enter)



# Preattentive Cues (What the Eye Sees "Immediately")

FAST COMPARISONS

**Position, length, slope**

Best for "how much" and trends.

FAST GROUPING

**Hue, shape, enclosure**

Best for "which group?"

# Attention + Working Memory (Why “Too Much” Breaks Charts)

ATTENTION

**Selective**

Viewers don't read everything.

MEMORY

**Limited**

Don't force “legend hunting.”

COMPARISON

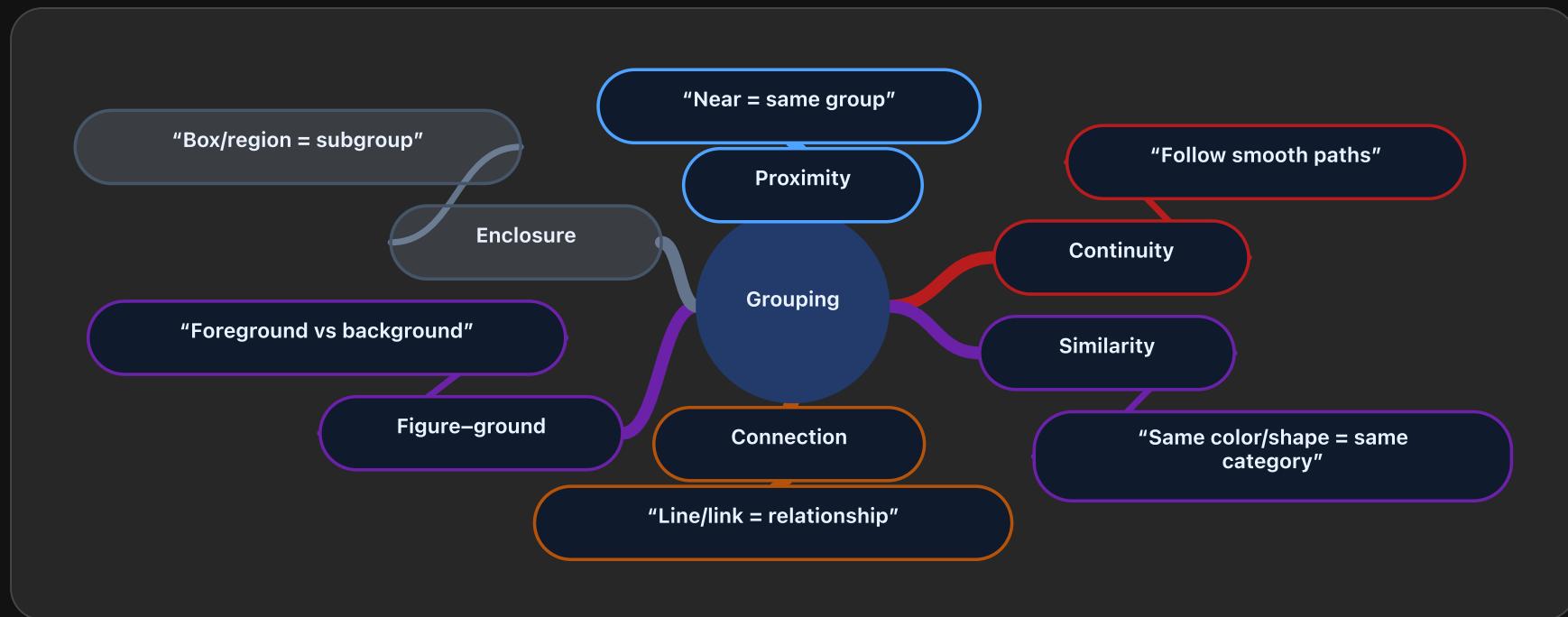
**Fragile**

Use shared scales + alignment.

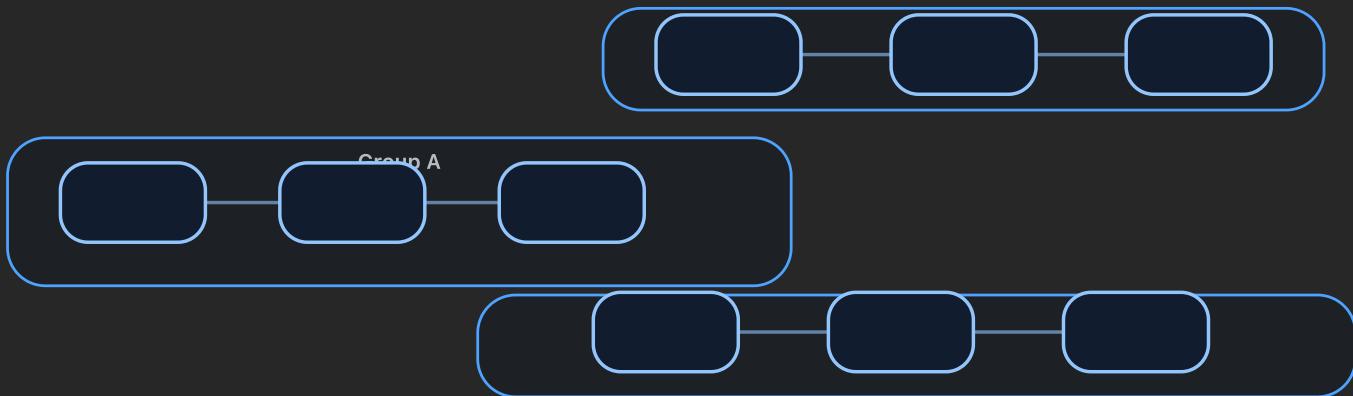
RULE OF THUMB

If your chart needs a paragraph to explain how to read it, redesign the chart.

# Gestalt Principles (How Viewers Group Marks)



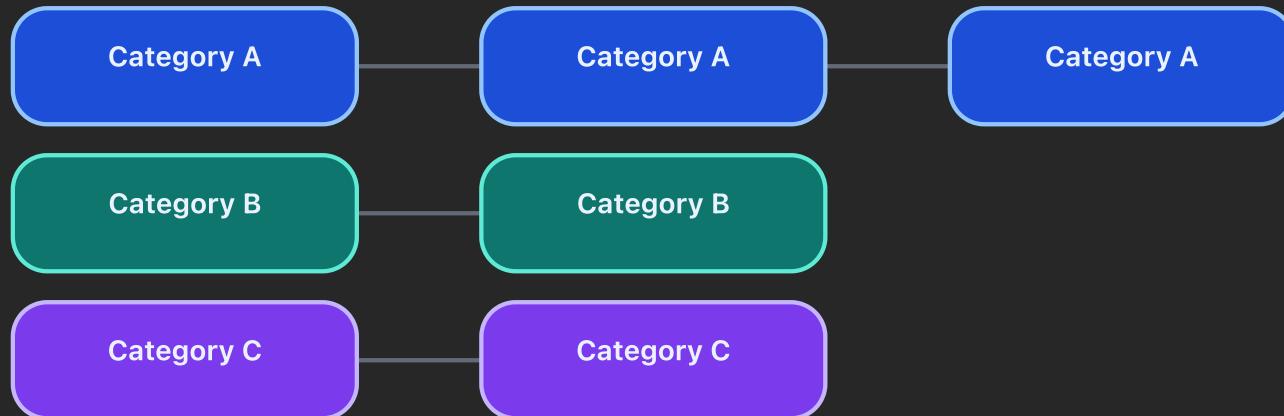
## Proximity: Grouping Without Extra Ink



DESIGN MOVE

**Use spacing and faceting to group — before adding more colors.**

# Similarity: When Color Creates Categories



USE SIMILARITY FOR

**Grouping, not magnitude**

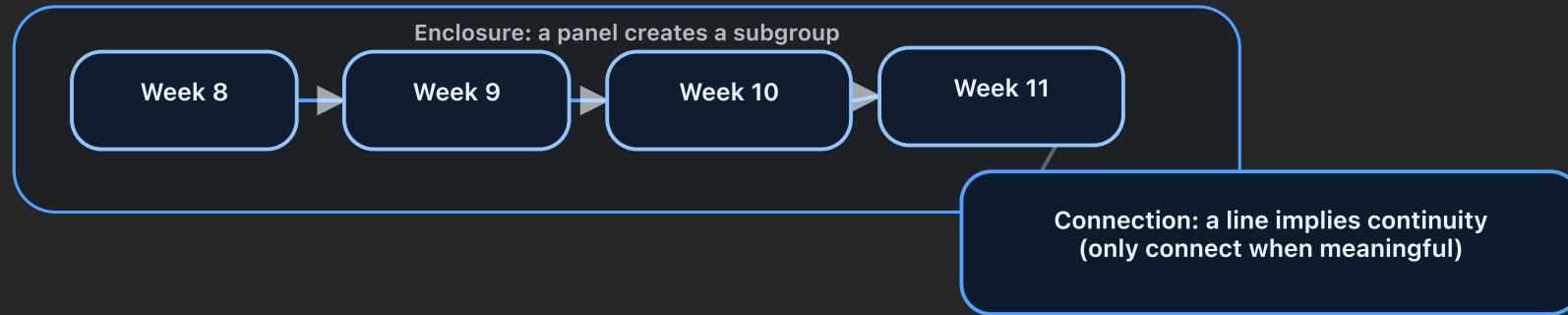
Hue answers "which group?"

COMMON MISTAKE

**Hue implies "how much"**

Prefer lightness for ordered data.

# Connection + Enclosure (When Lines and Boxes Mean Something)



# Visual Hierarchy (Make the Intended Reading Obvious)

## HIERARCHY RECIPE

**1 headline + 1 takeaway**

State what to look for before showing details.

## REDUCE NOISE

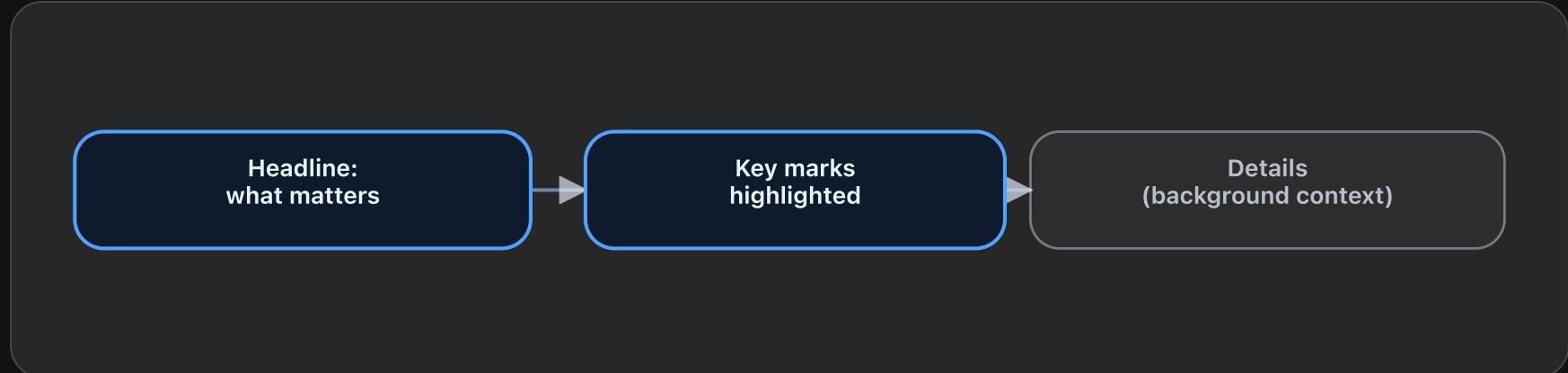
**De-emphasize non-data ink**

Light gridlines, fewer ticks, direct labels.

Headline:  
what matters

Key marks  
highlighted

Details  
(background context)



PART 2 · COLOR

# Mapping Color to data

Color is powerful — and easy to misuse.

# Color Has Three Useful Dimensions

Hue  
(which color)

Lightness  
(how bright/dark)

Chroma / Saturation  
(how intense)

Best for categories

Best for ordered  
magnitude

Best for emphasis,  
not scale

## KEY MESSAGE

**Hue answers “which group?” Lightness answers “how much?”**

# Three Palette Types You Should Know

## Qualitative

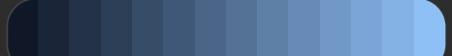
Categories



Blue Sky Green Orange Vermillion Purple

## Sequential

Low → High



0 50 100

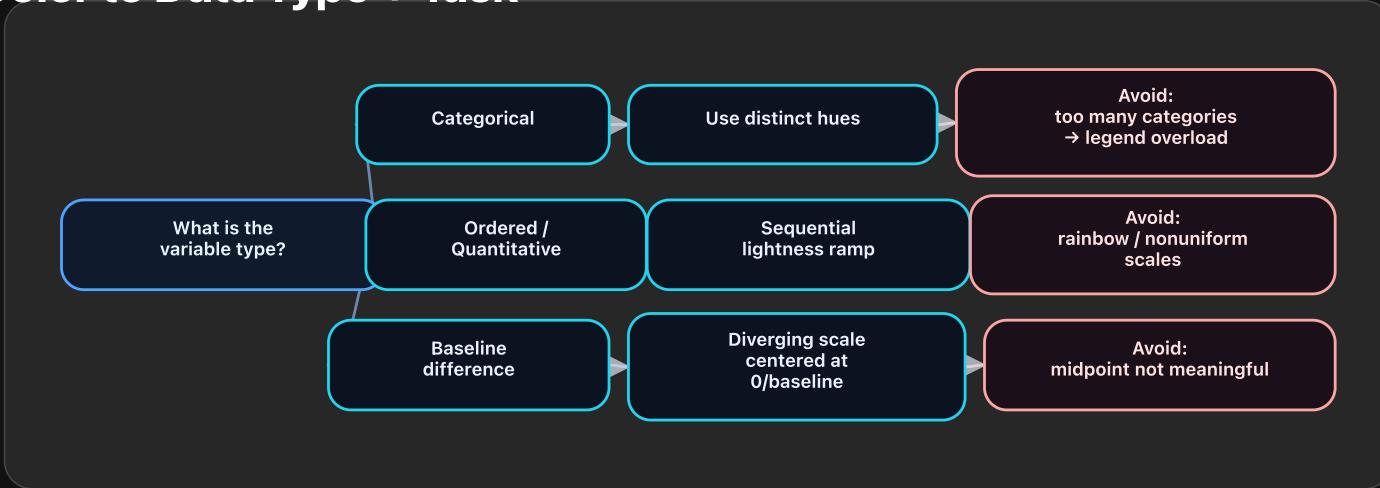
## Diverging

Below ↔ Above



-1.0 0.0 1.0

# Match Color to Data Type + Task



# Qualitative Palettes: Practical Rules

HOW MANY?

**$\leq 6$  categories**

Beyond that, use facets, grouping, or interaction.

HOW TO LABEL?

**Direct labels > legends**

Legends are fine, but don't make them mandatory.

HOW TO HIGHLIGHT?

**One accent**

Gray everything else, highlight the point of interest.

CONSISTENCY

**Same color = same meaning**

Across slides, charts, and the whole project.

## A Colorblind-Safer Qualitative Palette (Example)



USE IT LIKE THIS

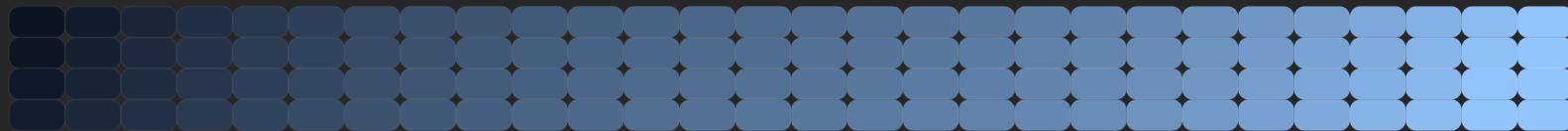
**Pick 4–6 colors + keep one neutral for baseline/context.**

## Sequential Scales (Magnitude: Low → High)

Lightness ramp (ordered magnitude)



Example: same values as a heatmap (higher = lighter)



### GOOD SCALE PROPERTY

**Lightness increases smoothly**

So order is visible even in grayscale.

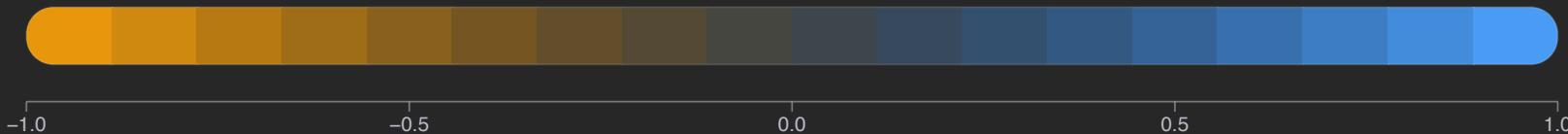
### COMMON FAILURE

**Hue changes create false boundaries**

Viewers “see” edges that aren’t real.

## Diverging Scales (Difference Around a Baseline)

Centered midpoint (baseline = 0)



Example: negative vs positive differences around the baseline



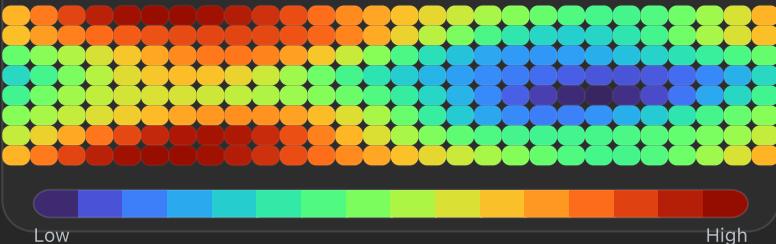
CRITICAL REQUIREMENT

**Only use diverging scales when the midpoint is meaningful (0, target, average).**

# The Rainbow Trap (Why It Misleads)

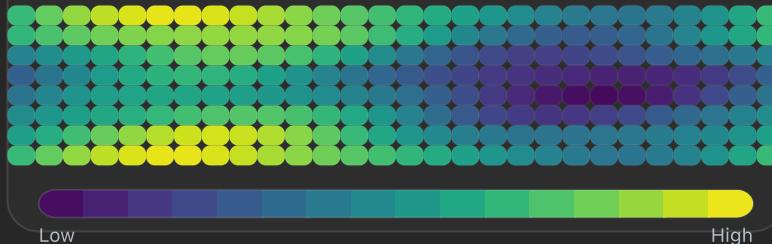
## Rainbow-like

Creates false boundaries



## Perceptual

Order visible in lightness



## WHY IT MISLEADS

- Non-uniform perception: some hues “pop.”
- False boundaries: hue edges look categorical.
- Not robust: breaks in grayscale and for CVD viewers.

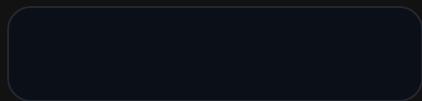
## DO INSTEAD

### Use lightness ramps (and label them)

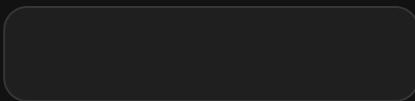
Sequential for magnitude; diverging only with a meaningful midpoint.

Include units + min/max (+ midpoint for diverging).

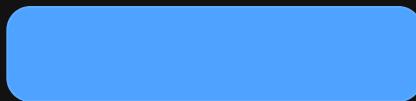
# Color + Contrast on Dark Backgrounds



Background



Surface



Accent



Text

## CONTRAST FOR TEXT

### **Readable labels**

Use off-white text; increase label size; avoid thin fonts.

## CONTRAST FOR MARKS

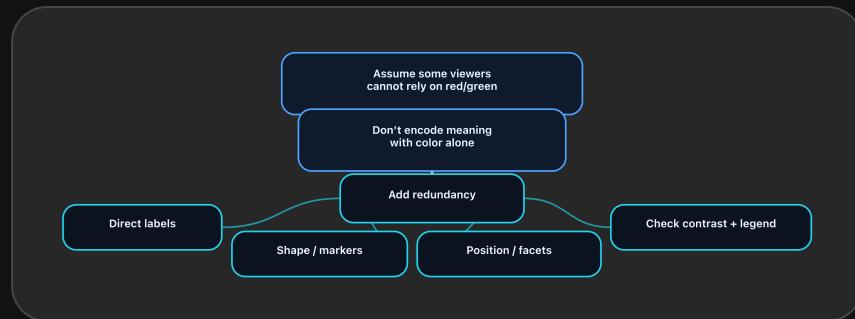
### **Visible data ink**

Thicker strokes; subtle gridlines; keep one strong accent.

## PRACTICAL CHECKLIST

**Neutrals + one accent · off-white text · thicker lines · subtle gridlines**

# Accessibility: CVD + Redundant Encoding



DO

## Design for robustness

Prefer blue/orange contrasts; use lightness ramps for magnitude; label directly.

AVOID

## Color-only meaning

Red/green-only signals; unlabeled scales; too many hues; required legend hunting.

# Legends Done Right (Small Details, Big Trust)

GOOD LEGEND

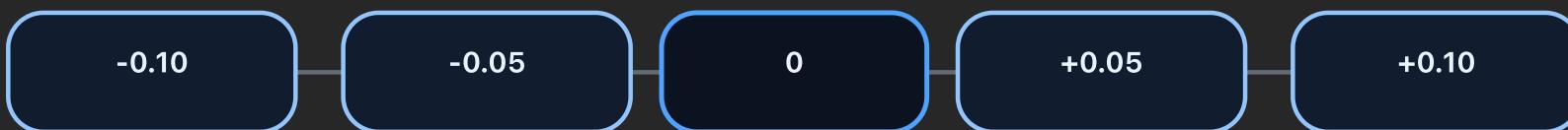
**Has units + ordering**

Includes midpoint for diverging scales.

BAD LEGEND

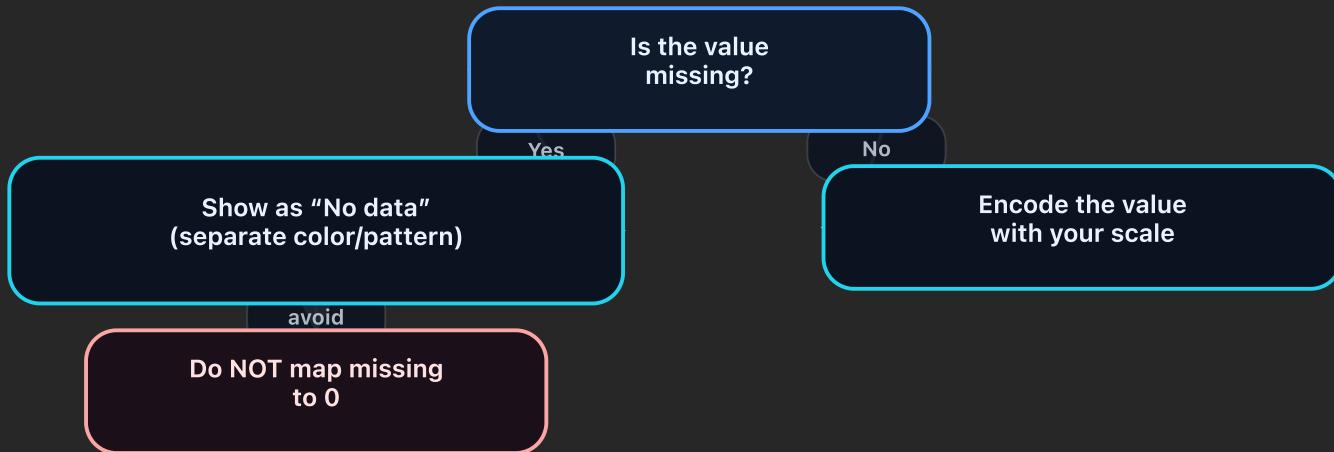
**Forces guesswork**

Unlabeled bins, unclear min/max, missing "no data".



-0.10      -0.05      0      +0.05      +0.10

# Missing Data ≠ Zero (A Common Interpretation Bug)



# Color for Emphasis (Highlight, Don't Paint Everything)

BASELINE CONTEXT

**Neutral**

Gray or low-saturation colors.

FOCUS

**One accent**

Use the accent only where you want attention.

Series A

Series B

Series C

Series D

# When Color Is the Wrong Tool

TOO MANY CATEGORIES

**Use small multiples**

Facets + consistent scales beat 12-color legends.

PRECISE COMPARISON

**Use position**

Dot plots and aligned bars are more accurate.

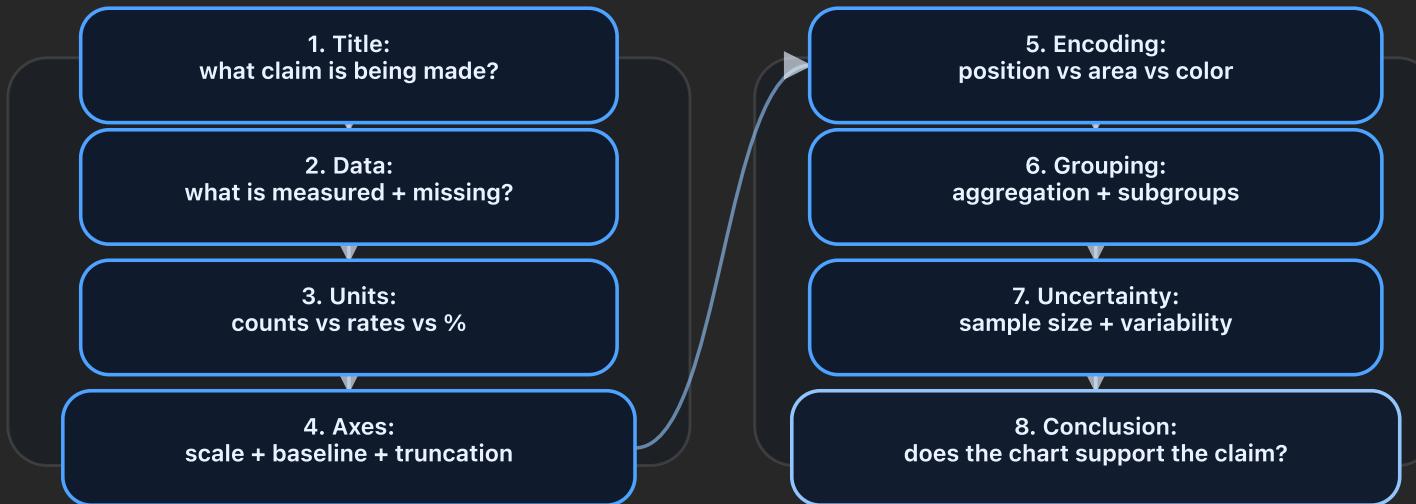


PART 3 · CHART READING

# Read charts like a skeptic

Trust the data, but verify the encoding.

# An 8-Step Chart Reading Checklist



# Pitfall: Truncated Axis (Especially for Bars)

## WHY IT MISLEADS

### Bars encode length from a baseline

If the baseline is not zero, the visual difference is inflated.

## WHEN ACCEPTABLE

### Use dots/lines for nonzero baselines

Or clearly mark axis breaks and explain them.

**Bar chart (baseline = 0)**



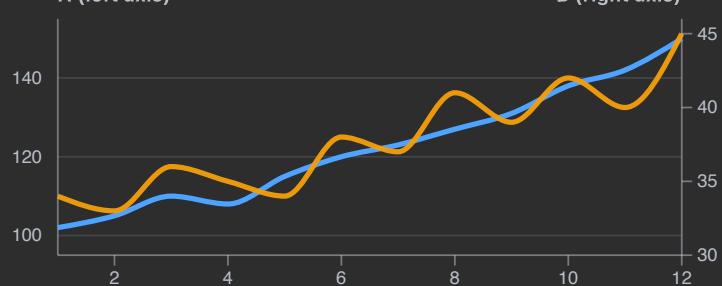
**Dot plot (zoomed axis)**



# Pitfall: Dual Y-Axes (Two Stories in One Chart)

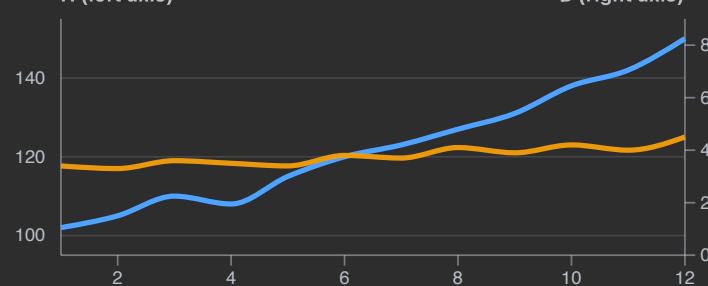
## Right axis squeezed

Looks "correlated"



## Right axis expanded

Looks "uncorrelated"



# Pitfall: 3D and Perspective

## PERCEPTION PROBLEM

**3D turns accurate length comparisons into ambiguous area comparisons.**

## WHAT 3D ADDS

**Decoration, not information**

It makes the reading harder, not better.

## PROFESSIONAL FIX

**Use 2D with labels**

Add annotation if you need emphasis.

## Pitfall: Area Encodings (Bubbles, Pies, Stacked Areas)

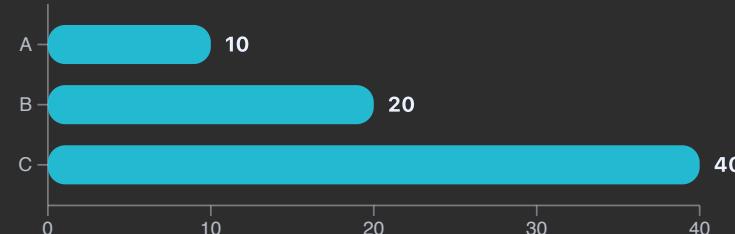
### Bubbles (area)

Hard to compare precisely



### Bars (length)

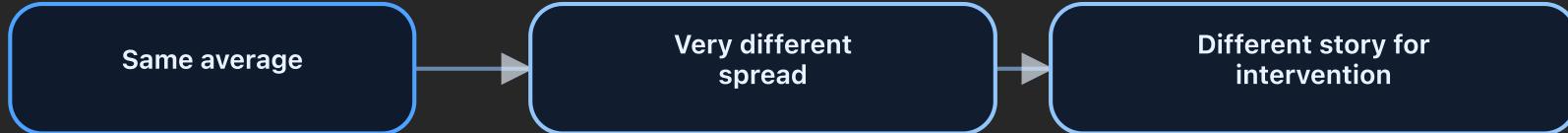
Aligned comparisons



### DESIGN GUIDANCE

If comparison matters, avoid area-only charts. Use aligned position instead.

# Pitfall: “Average” Hides Distribution



READER MOVE

**Ask: what is the distribution?**

Outliers? bimodal? wide variance?

DESIGNER MOVE

**Show uncertainty or spread**

Box plots, intervals, or small multiples.

# Pitfall: Counts vs Rates (Normalization Errors)

Comparing groups  
with different sizes

Counts can  
mislead

Use rates or  
per-capita measures

Always show  
denominator (n)

# Pitfall: Binning and Scale Choices (Histograms, Heatmaps)

## BINNING CHOICE

**Controls what patterns appear**

Too few bins hide structure; too many bins add noise.

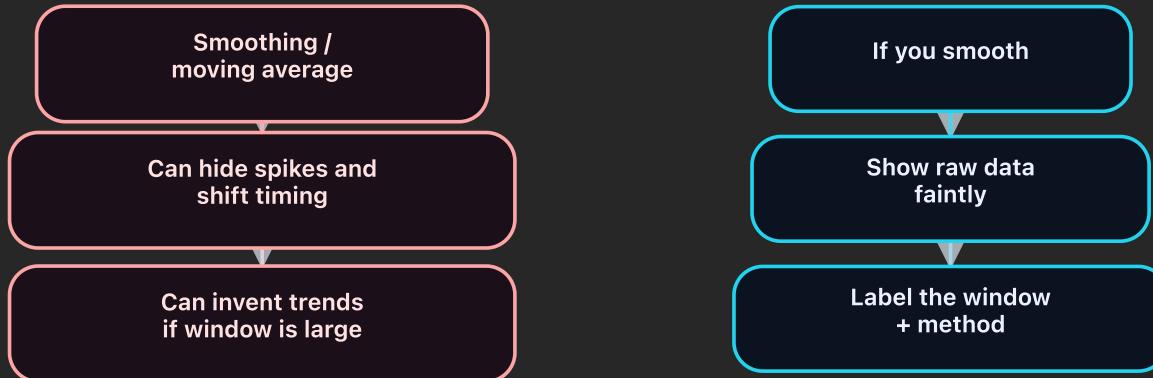
## SCALE CHOICE

**Controls contrast**

Linear vs log can change perceived differences.



## Pitfall: Smoothing (It Can Hide or Invent Changes)



# Pitfall: Uncertainty Missing (False Precision)

READER MINDSET

**If you see a single line, ask: how variable is it?**

ADD UNCERTAINTY

**Intervals or distributions**

Error bars, bands, dot plots, or box plots.

AT MINIMUM

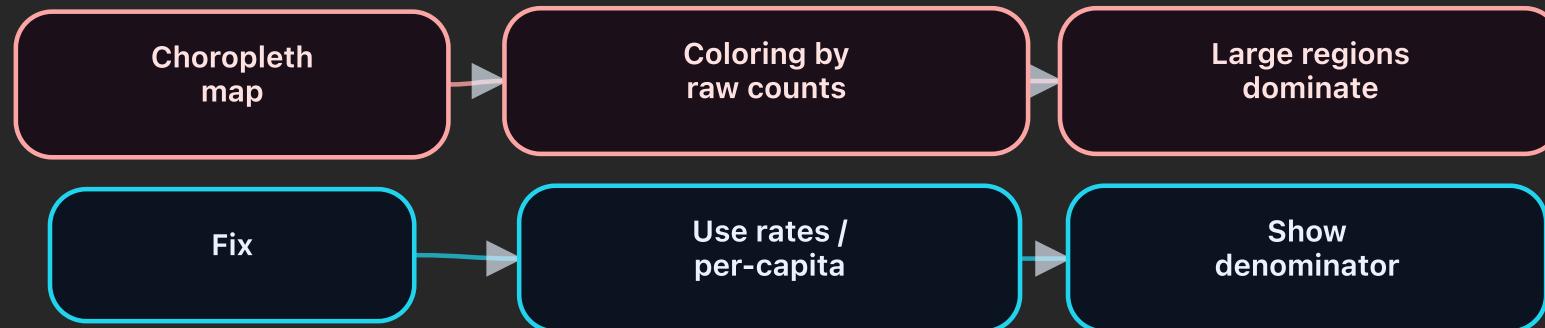
**Show sample size**

So viewers can judge stability.

# Pitfall: Cherry-Picked Time Windows



## Pitfall: Choropleths of Counts (Map Misuse)



## Pitfall: Inconsistent Scales Across Panels



# Pitfall: Category Order and Sorting

## UNSORTED CATEGORIES

### **Hide ranking patterns**

Readers waste time scanning.

## SORTED CATEGORIES

### **Make comparisons effortless**

Sort by value, by meaningful order, or by grouping.

Sort rule

Rank by value

Or use domain  
order

Or group + sort  
within group

# Pitfall: Color Implies Meaning You Didn't Intend

COMMON FAILURE

**Sequential color on categories implies order.**

READER CHECK

**Is the color scale labeled?**

If not, don't assume magnitude.

DESIGNER FIX

**Use qualitative hues for categories**

Reserve sequential/diverging for ordered measures.

PART 4 · PRACTICE

# Audit, then redesign

Build trust by catching problems early.

# A Fast Audit Checklist (Before You Trust a Chart)

## CLAIM

**What is this chart trying to prove?**

Is the claim specific and verifiable?

## DATA

**What is included/excluded?**

Any missing values, filtering, or transformations?

## ENCODING

**Are channels appropriate?**

Position vs area; color type matches data type.

## SCALE

**Baselines + axes correct?**

Truncation, log scales, inconsistent panels.

## UNCERTAINTY

**Could noise or sample size change the story?**

Look for n, intervals, or distributions.

## Critique Drill (In Groups)

### ACTIVITY

#### **Find 3 problems and propose 3 fixes.**

- Identify the *claim* the chart is making (1 sentence).
- List 3 potential issues (axes, color, encoding, aggregation, missingness).
- Propose 3 fixes (chart type, scale, palette, labels, transforms).
- Decide whether the original claim still holds after your fixes.

## "Spot the Pitfall" (Quick Check)

### SCENARIO

**A bar chart shows a tiny change as a huge jump.**

What do you check first?

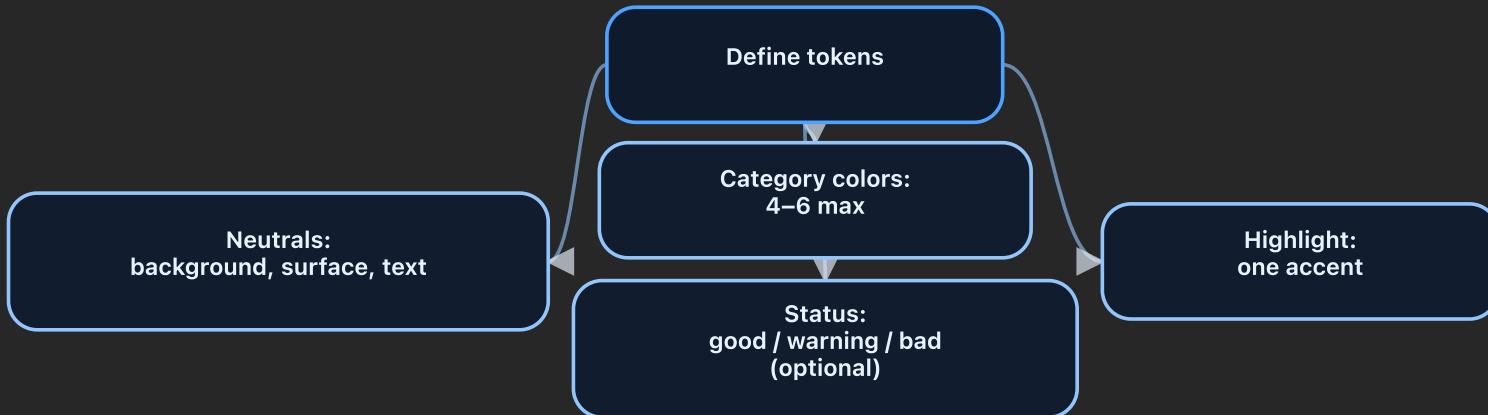
### SCENARIO

**A heatmap looks like it has "bands."**

What do you check first?

- Bar chart: check the y-axis minimum and baseline.
- Heatmap: check the color scale type (sequential? labeled?) and whether it's uniform in lightness.
- Both: check if the claim matches the data + transformations.

# Build a Simple Color System for Your Project



## OUTCOME

Your charts look cohesive because your colors are consistent.

# Wrap-up + Practice

## TAKEAWAYS

- Use **position/length** for accurate comparisons; avoid area for precision tasks.
- Use **hue** for categories, **lightness** for magnitude, **diverging** for baseline differences.
- Design accessibly: **contrast + redundancy + labeled scales**.
- Read charts with a checklist: claim → data → units → axes → encoding → aggregation → uncertainty.

**Ethics:** Be persuasive by being clear — not by manipulating perception.

## WHAT TO PRACTICE

- Critique one real chart (write the claim + 3 issues + 3 fixes).
- Redesign one misleading choice (axis, encoding, palette, aggregation).
- Apply accessibility basics (contrast, direct labels, “no data” handling).
- Reuse a consistent palette system across your project.

## References (Recommended)

**Ware, C. (2012)**

Information Visualization: Perception for Design  
(3rd ed.)

[Publisher page](#)

**Munzner, T. (2014)**

Visualization Analysis & Design

[Author page](#)

**Cleveland, W. S., & McGill, R. (1984)**

Graphical perception: Theory, experimentation,  
and application

<https://doi.org/10.1080/01621459.1984.10478080>

**Okabe, M., & Ito, K. (2002)**

Color Universal Design (palette guidance)

<https://jfly.uni-koeln.de/color/>