Introduction to Visualization

Introduction: What Is Visualization? History of Visualization, Relationship between Visualization and Other Fields the Visualization Process, Introduction of visual perception, visual representation of data, Gestalt principles, information overloads.

What is Visualization?

- Visualization as the communication of information using graphical representations.
- Representing data through visual elements
- Enhances understanding and decision-making
- Helps spot patterns, trends, and outliers

What is Data?

Data refers to raw facts, statistics, or information collected or stored in a structured or unstructured form. Data can take various forms, such as text, numbers, images, videos, and more. It is the foundation of all information and knowledge and is used in various fields for analysis, decision-making, and understanding trends and patterns.

Data can be categorized into two main types:

- **Structured Data:** This type of data is organized into a specific format, such as tables or databases, and is easily searchable and analyzable. Examples include spreadsheets, relational databases, and CSV files.

- **Unstructured Data:** Unstructured data lacks a specific format and can include text documents, social media posts, images, audio recordings, and more. Analyzing unstructured data often requires advanced techniques like natural language processing and image recognition.

Where to Find Data?

You can find data from various sources, depending on your specific needs:

- **Open Data Portals:** Many governments and organizations provide free access to a wide range of data through open data portals. Examples include Data.gov (United States) and data.gov.uk (United Kingdom).
- **Data Repositories:** Academic institutions, research organizations, and data enthusiasts often share datasets on platforms like Kaggle, GitHub, and the UCI Machine Learning Repository.
- **APIs (Application Programming Interfaces):** Some websites and services offer APIs that allow you to programmatically access and retrieve data. Examples include Twitter API, Google Maps API, and financial market APIs.
- **Web Scraping:** You can extract data from websites using web scraping tools and libraries like BeautifulSoup and Scrapy. However, be mindful of the website's terms of use and legal restrictions.
- **Surveys and Surveys:** You can conduct your own surveys or collect data through questionnaires and interviews.
- **IoT Devices:** Internet of Things (IoT) devices generate vast amounts of data that can be used for various purposes.
- **Commercial Data Providers:** Some companies specialize in selling datasets for specific industries, such as market research, finance, and healthcare.

Foundations for Building Data Visualizations:

Creating effective data visualizations requires a strong foundation in several key areas:

- **Data Analysis:** Before creating visualizations, you should thoroughly analyze your data to understand its structure, relationships, and any patterns or trends. Exploratory data analysis (EDA) techniques can help with this.
- **Statistical Knowledge:** Understanding basic statistics is essential for making meaningful interpretations of data. Concepts like mean, median, standard deviation, and correlation are commonly used in data visualization.
- **Domain Knowledge:** Having knowledge of the specific domain or subject matter related to your data is crucial for creating contextually relevant visualizations. It helps you ask the right questions and provide valuable insights.
- **Visualization Tools:** Familiarize yourself with data visualization tools and libraries such as matplotlib, Seaborn, ggplot2, D3.js, and Tableau. Each tool has its strengths and can be used for different types of visualizations.
- **Design Principles:** Study design principles, including color theory, typography, and visual hierarchy, to create visually appealing and effective visualizations. Avoid common pitfalls like misleading visualizations.
- **Interactivity:** Learn how to add interactive elements to your visualizations to engage users and allow them to explore the data. This can be achieved using tools like JavaScript, Python libraries, or dedicated visualization software.

Example: Analyzing Student Performance Data

🎯 **Goal:**

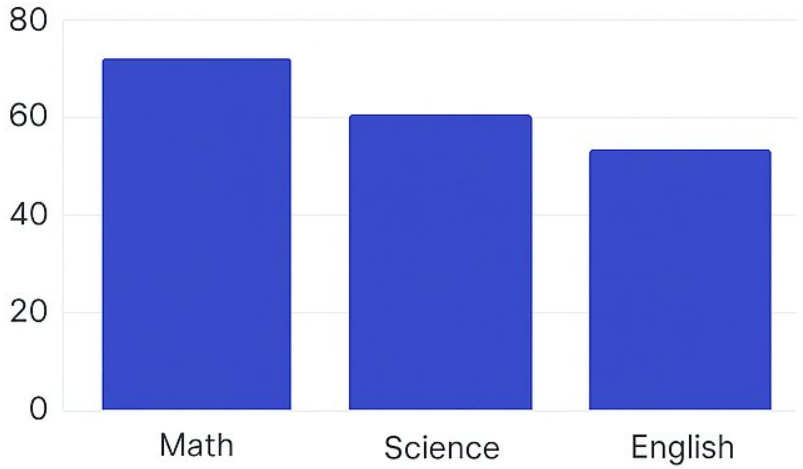
Create an interactive dashboard to help a school analyze students' performance across subjects and identify areas for improvement.

Foundation	Real-Time Example: Student Performance Dashboard
Data Analysis	Load student scores in Math, Science, and English. Use Pandas to perform EDA—mean, median, trends, missing values.
Statistical Knowledge	Calculate statistics like mean, standard deviation, and correlation between subject scores using NumPy or Pandas.
Domain Knowledge	Understand grading policies and curriculum structure. For example, science includes lab work affecting scores.
Visualization Tools	Use tools like Matplotlib, Seaborn, Plotly, or Tableau to create charts: bar graphs, heatmaps, trend lines, etc.
Design Principles	Apply color theory (avoid red-green), add axis labels, maintain consistent layout, and avoid misleading visuals.
Interactivity	Use Plotly Dash/Tableau/Power BI to add dropdowns (select class/semester), hover tooltips, and filters for low scores.

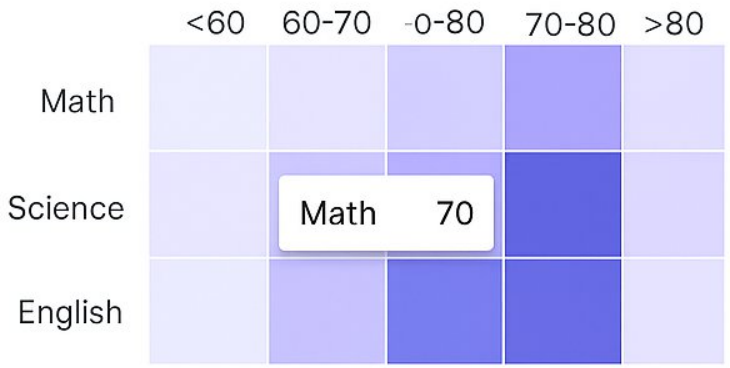
All

Student Performance Dashboard

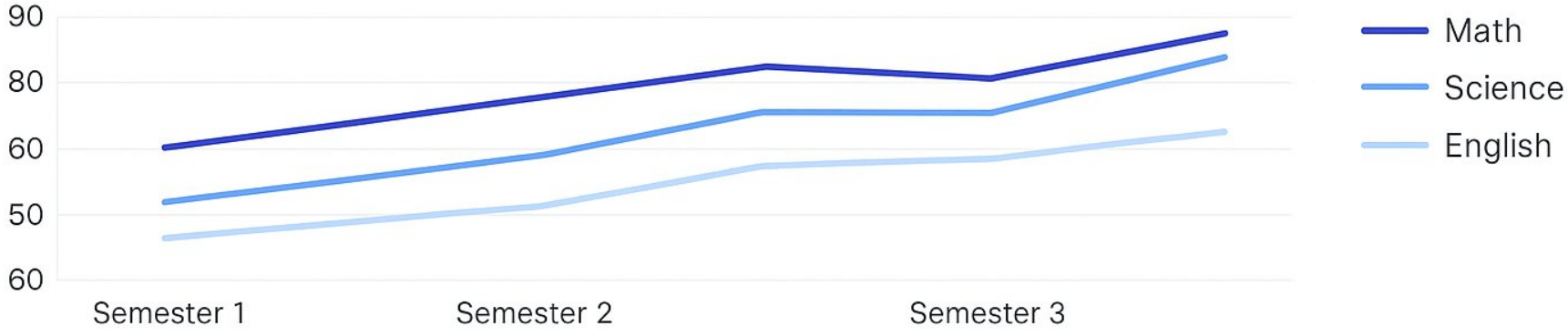
Average Scores by Subject



Score Distribution

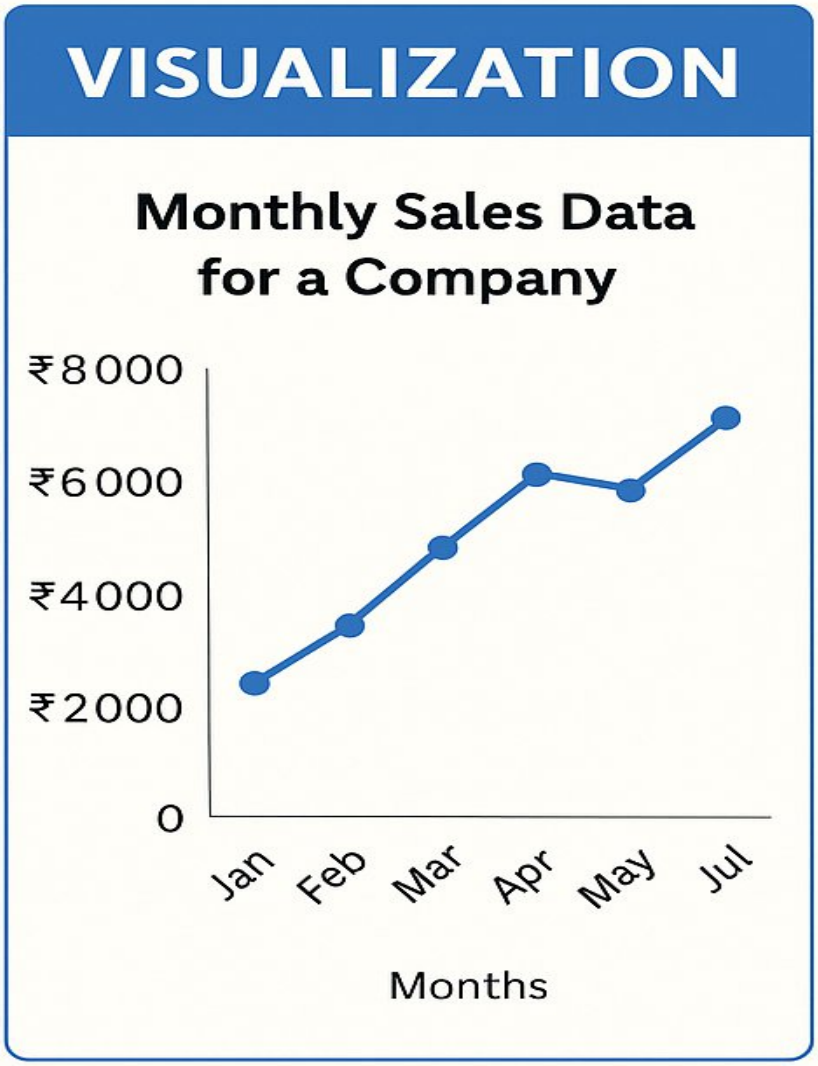


Score Trends Over Time



Visualization vs. Text

VISUALIZATION



TEXT

In January, the sales were ₹40,000. In February, they increased to ₹50,000. March recorded ₹65,000 in sales, while April slightly dropped to ₹60,000. In May, the company made ₹70,000. June saw a peak of ₹85,000. July dipped to ₹75,000.

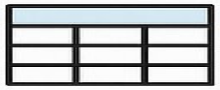
Examples of Visualization in Daily Life

#	Example	Type of Visualization	Purpose
1	GNP of the U.S. (as a number)	Numeric Display (KPI, Dashboard Tile)	Quick understanding of a key economic metric
2	Table in a newspaper	Tabular Data	Detailed comparison of values mentioned in an article
3	Train/Subway map with times	Map + Timetable Overlay	Navigation and time planning for public transport
4	Regional road map	Geographic Map	Route selection and navigation
5	Weather chart (storm movement)	Dynamic Weather Map/Chart	Forecast and decision-making (e.g., travel, outings)
6	Graph of stock market activities	Line Chart / Candlestick Graph	Financial trend analysis
7	Painkiller effectiveness comparison	Bar Chart / Dot Plot	Comparative effectiveness of products
8	3D reconstruction of injured knee from CT scan	3D Medical Visualization	Diagnosis, surgery planning
9	Instruction manual for assembling a bicycle	Step-by-step Illustrated Guide	Visual learning and task completion
10	Highway sign (curve, merging lanes, intersection)	Pictogram / Symbolic Graphic	Quick roadside communication of driving instructions

Examples of Visualization

19.537

A simple formatted number representing a single item of interest, such as the gross national product (GNP) of the U.S.



A table in a newspaper, representing data being discussed in an article



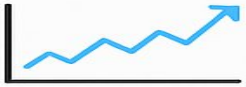
A train and subway map with times used for determining train arrivals and departures



A map of the region, to help select a route to a new destination



A weather chart showing the movement of a storm front that might influence your weekend activities



A graph of stock market activities that might indicate an upswing (or downturn) in the economy



A plot comparing the effectiveness of your pain killer to that of the leading brand



A 3D reconstruction of your injured knee, as generated from a CT scan



An instruction manual for putting together a bicycle, with views specific to each part as it is added



A highway sign indicating a curve, merging of lanes, or an intersection

simplebefomics

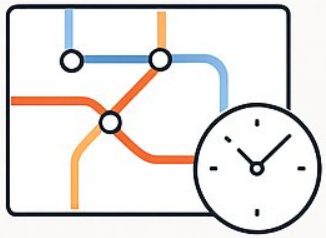
Examples of Visualization in Daily Life



Gross national product (GNP) of the U.S.



Table in a newspaper



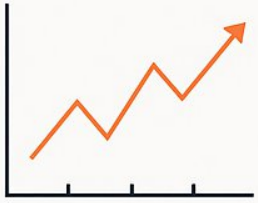
Train and subway map with times



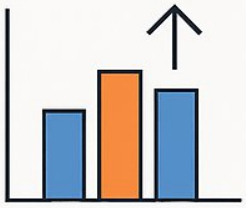
Map of the region



Weather chart with storm front



Graph of stock market activities



Plot comparing painkiller effectiveness



3D reconstruction of injured knee



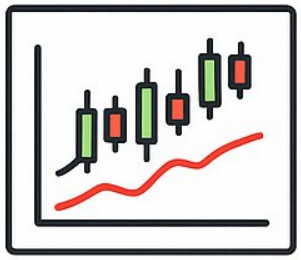
Instruction manual for bicycle



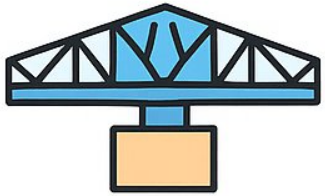
Highway sign

Professional Applications of Visualization

Domain	Visualization Example
Finance & Economics	📈 Financial and stock market analysis charts (e.g., candlestick, moving averages)
Engineering	🛠️ 3D CAD visual of a rotary bridge or system simulation in mechanical/civil engineering
Healthcare	MRI scans of breast cancer visualized for diagnosis and treatment planning
Astronomy	☄️ Visualizing comet paths over time using orbital simulation charts
Behavioral Science	🚬 Heatmaps or bar charts of human smoking behavior by age, region, etc.
Insurance / Actuarial	📊 Graphs of risk probabilities, lifespan projections, and data-driven policy simulations
Simulation Sciences	🔁 Visualization of a fluid simulation or a physical phenomenon in motion
Social Networks	👥 Network graphs showing Facebook friends and how they interconnect
Marketing / Advertising	🎯 Eye-catching posters, infographics, and ad visuals to influence decision-making



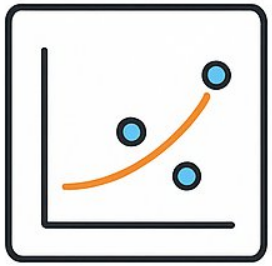
Finance & Economics
Financial and stockmart analysis charadavise



Engineering
3D CAD visual of a rotary bridge



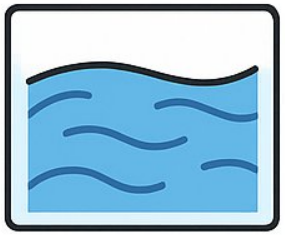
Mealthcare
MRI scan of breast cancer



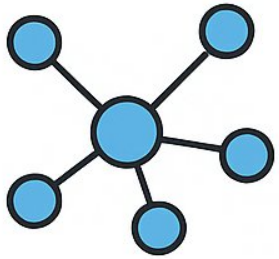
Astronomy
Visualizing comet at diagnossis



Insurance / Actuarial
Graphs of risk probabilities



Simulation Sciences
Visualization of a fluid simulation



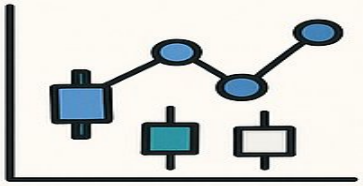
Social Networks
Network graphs of IF friends and interconn



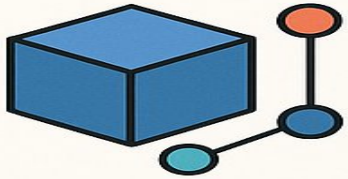
Marketing / Advertising
Eye-catching posters and ads visuals

Professional Appections of Visualization

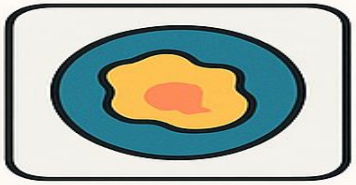
Suitable Visualization Techniques



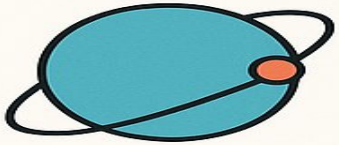
Candistick Chart / Line Graph



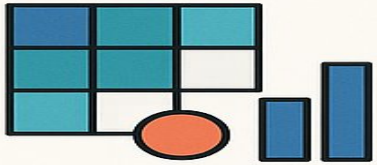
3D CAD Models / System Diagrams



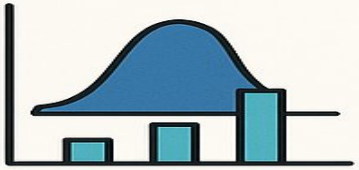
Medical Imaging



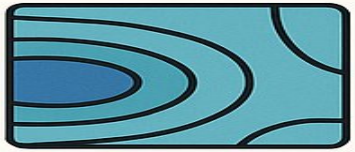
Orbit Path Visualization / Time Series Animation



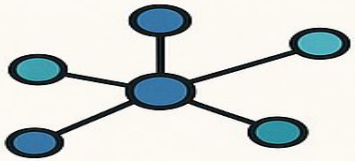
Heatmap / Bar Chart / Demographic Bubble Chart



Histograms / Probability Distribution Graphs



Flow Fields / Surface Plots / Animated Simulations



Network Graph / Force-Directed Graph



Infographics / Dashboards / A/B Comparison Charts

- In what kinds of situations are visualizations effective?
- What types of information can and cannot be visualized?
- How many different ways are there to show the same data, and which ones are best for particular circumstances?

Why Is Visualization Important?

🔍 1. Human Perception

•Humans rely heavily on sight to process and interpret information.

•Visualization taps into our **natural pattern recognition abilities** to make data **more intuitive**.

2. Impact on Decision-Making

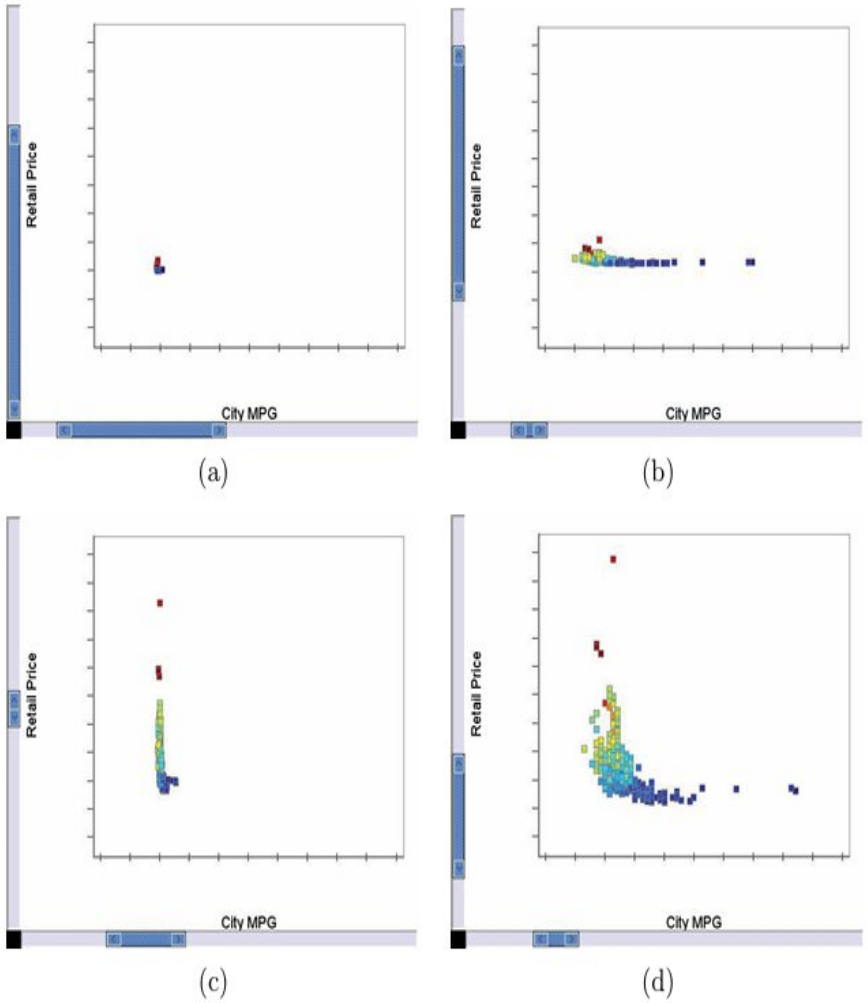
•**Presentation style** of data can **influence decisions**.

•The **same data** can lead to **different interpretations** based on **how it is visualized**.

Example: Data Scaling Effects

We can show this using **4 different versions** of the same scatter plot:

Figure	Description	Perceived Pattern
1.1(a)	Uniform scale on both axes (zoomed out)	Data appears like a blob (clustered)
1.1(b)	Y-axis stretched (vertical scale exaggerated)	Linear pattern appears horizontal
1.1(c)	X-axis stretched (horizontal scale exaggerated)	Linear pattern appears vertical
1.1(d)	True scale using data's min-max for both axes	Actual trend appears (e.g., diagonal line)



History of Visualization

- • Ancient maps, star charts, cave drawings
- • 1786: William Playfair’s bar & line charts
- • 1854: John Snow’s cholera map
- • 19th century: Florence Nightingale's coxcomb charts
- • Modern: Interactive & real-time dashboards

Ancient Beginnings
|
|-- Prehistoric Cave Paintings (~30,000 BCE)
|-- Early Symbols & Pictographs
|
Ancient Civilizations
|
|-- Hieroglyphs & Early Maps (Egyptians, Mesopotamians)
|-- Greek Geometric & Cartographic Visualizations
|
Medieval Period
|
|-- Illuminated Manuscripts & Religious Diagrams
|-- Symbolic Maps (Mappa Mundi)
|
Renaissance & Scientific Revolution
|
|-- Leonardo da Vinci’s Anatomical Drawings
|-- Printing Press Enables Wider Spread
|-- More Accurate Maps from Exploration
|-- Early Statistical Graphics Begin
|
18th & 19th Centuries
|
|-- William Playfair invents Bar, Line, Pie Charts
|-- Florence Nightingale’s Polar Area Chart
|-- Charles Minard’s Flow Map (Napoleon’s Campaign)
|
20th Century
|
|-- Formal Statistical Graphics Theory
|-- Computer Graphics Emergence (1950s+)
|-- Visualization in Medicine, Weather, Business
|-- Start of Interactive Visualization
|
21st Century
|
|-- Big Data & Interactive Dashboards
|-- Real-time & AI-assisted Visualization
|-- VR, AR Visualization Technologies
|-- Democratization via Tools like D3.js, Tableau

Ancient Beginnings (≈ 2000 BCE – 1500 CE)

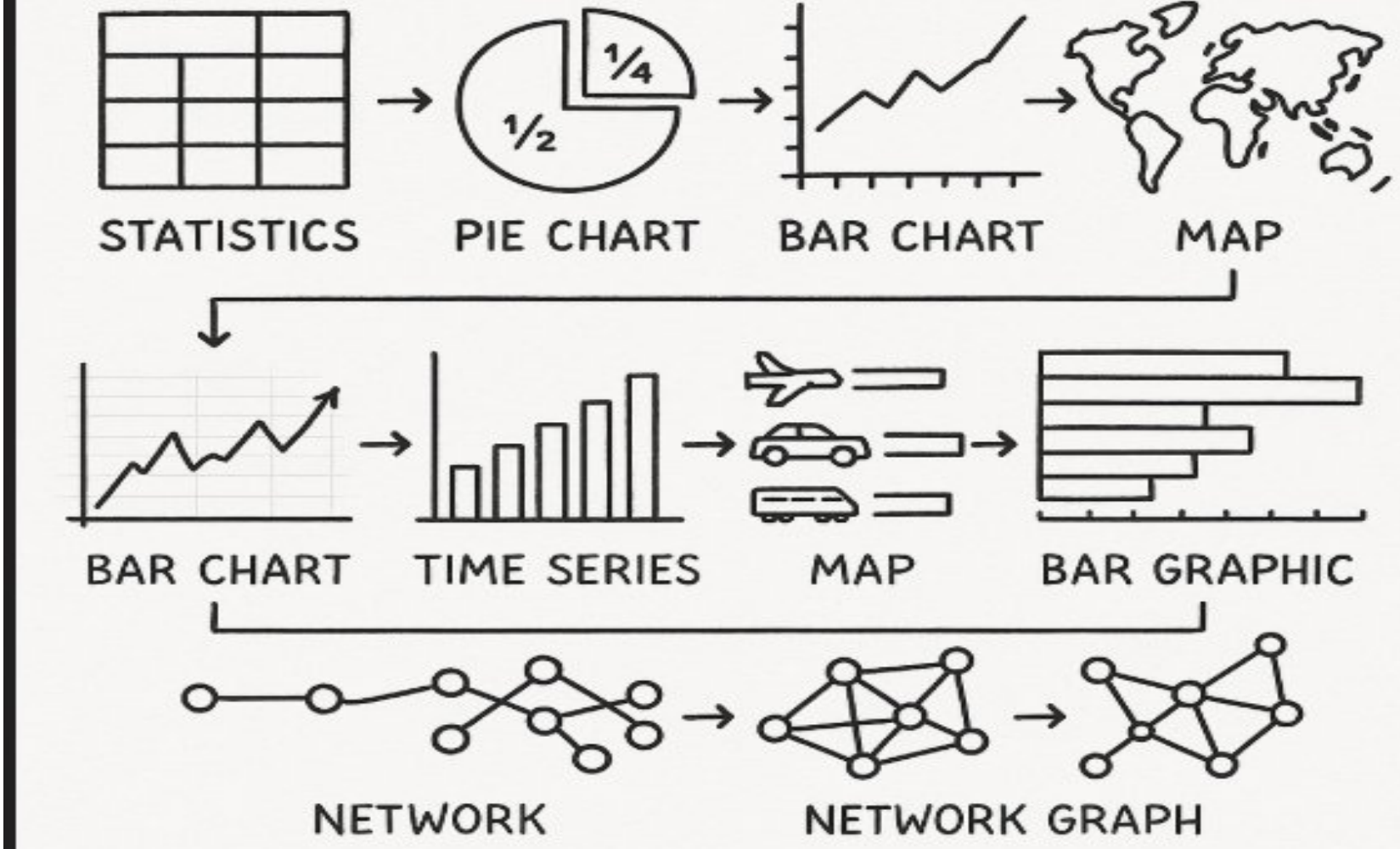
- ✓ Babylonian clay tablets (maps, astronomy)
- ✓ Egyptian surveying charts, Nile flood records
- ✓ Greek & Roman cartography
- ✓ Islamic Golden Age star charts and geometry

- **Early Modern Era (1500–1800)**
- ✓ First world maps (e.g., Mercator Projection – 1569)
- ✓ William Playfair (late 1700s): bar chart, pie chart, line chart
- **Scientific Revolution (1800–1900)**
- ✓ Florence Nightingale's coxcomb charts (1857)
- ✓ Charles Joseph Minard's Napoleon march flow map (1869)
- ✓ Statistical atlases and early demographic maps
- **20th Century**
- ✓ Tufte's work on visual integrity
- ✓ Rise of computers: IBM, UNIVAC era
- ✓ Early plotting software (e.g., 1960s–1980s)

21st Century

- ✓ Big Data and Interactive Visualization
- ✓ Tools: Tableau, D3.js, Power BI
- ✓ AI-powered visual analytics

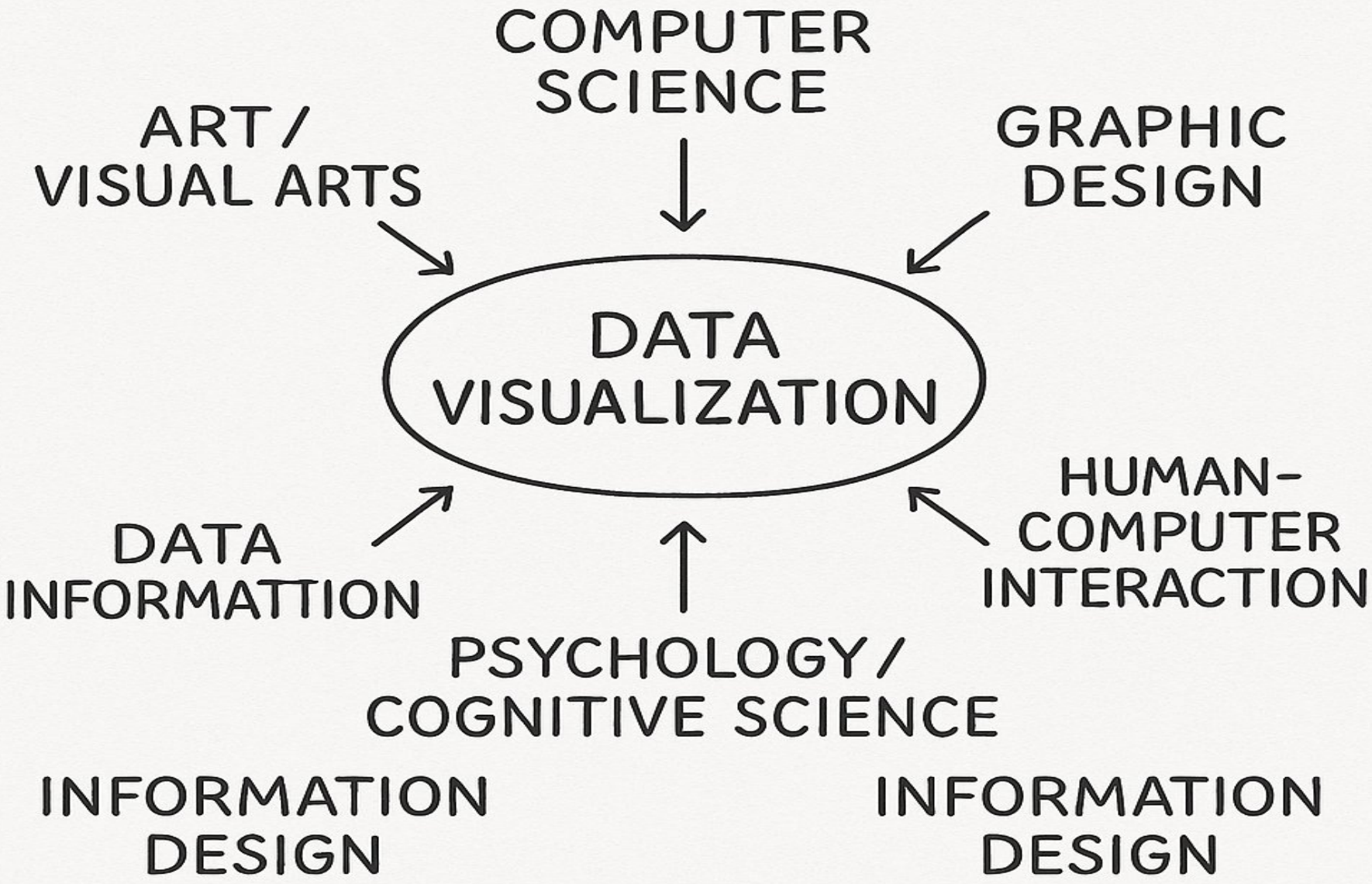
DATA VISUALIZATION HISTORY



Relationship with Other Fields

- • Statistics – Trends & distributions
- • Computer Science – HCI, AI, Data Mining
- • Design – Aesthetics & usability
- • Cognitive Science – Perception
- • Journalism – Storytelling with data

RELATIONSHIP WITH OTHER FIELDS

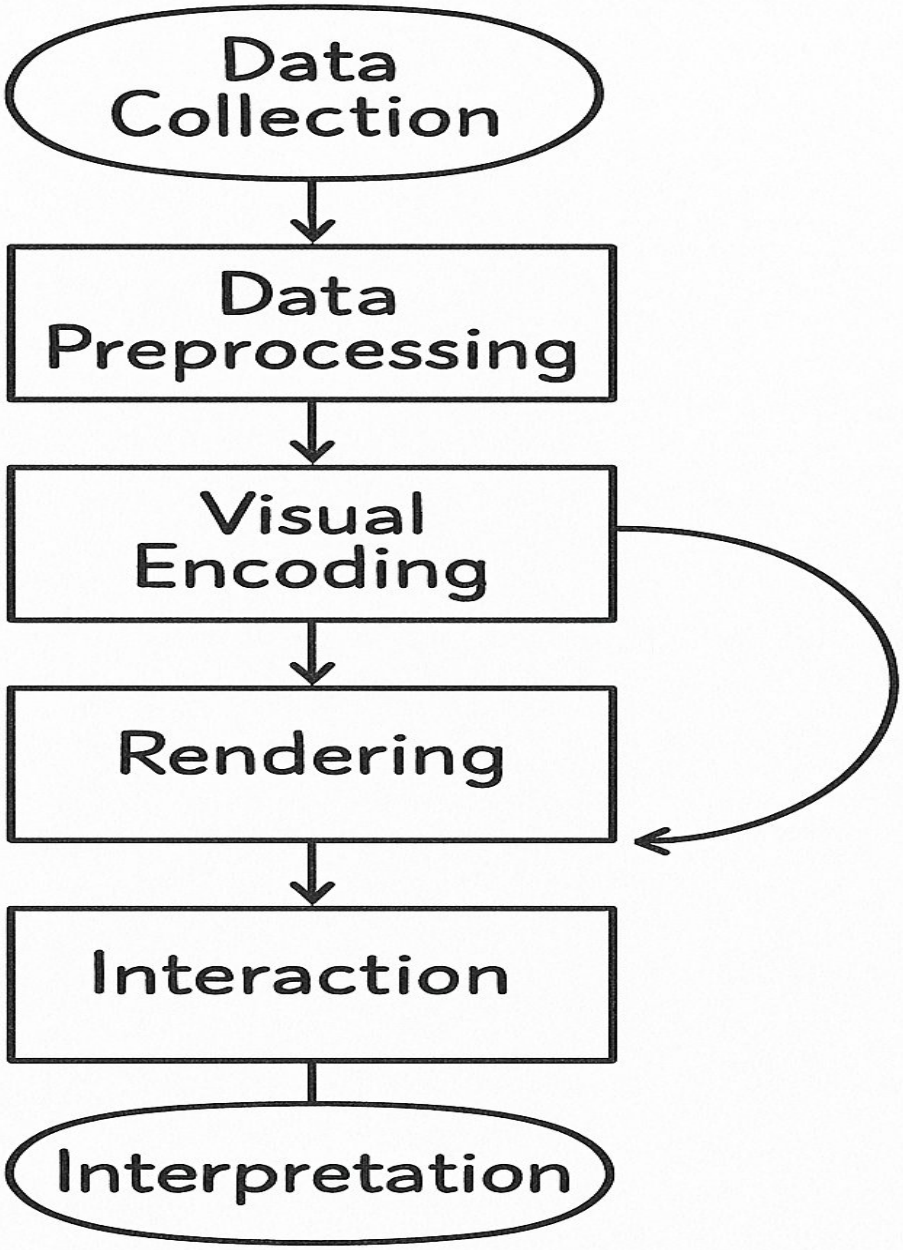


The Visualization Process

- 1. Data Collection
- 2. Preprocessing
- 3. Mapping data to visuals
- 4. Design (color, layout)
- 5. Interaction (if needed)
- 6. Interpretation

Step	Description
1. Data Collection	Gathering data from sources (surveys, sensors, databases, etc.)
2. Data Preprocessing	Cleaning, filtering, transforming, aggregating, or normalizing the data
3. Data Mapping	Deciding how to represent data dimensions (e.g., x-axis = time, y-axis = sales)
4. Visual Encoding	Choosing visual elements like bars, lines, dots, colors, or shapes
5. Rendering	Drawing the visual using tools (matplotlib, D3.js, Tableau, etc.)
6. Interaction *(optional)*	Adding interactivity: zoom, filter, hover, etc.
7. Interpretation	The user analyzes, explores, or draws conclusions from the visualization

THE VISUALIZATION PROCESS



Example: **COVID-19 Case Trends Visualization**

Step	Description
1. Data Collection	Johns Hopkins University collects global COVID-19 case numbers from health departments and hospitals.
2. Data Preprocessing	Data is cleaned to remove duplicates, fix missing values, convert dates to a standard format, and normalize case counts per country.
3. Visual Encoding	Decide how to represent time on the x-axis, and number of daily cases on the y-axis. Countries are shown as different colored lines.
4. Rendering	Use software like **Tableau**, **Python (Matplotlib/Seaborn)**, or **Power BI** to render the line graph.
5. Interaction	Add filters to select specific countries, date ranges, or show tooltips when hovering over a point.
6. Interpretation	Users explore the graph and interpret trends—e.g., a spike in cases after a holiday or drop after lockdown measures.

THE VISUALIZATION PROCESS

DATA COLLECTION
Johns Hopkins University collects global COVID-19 case numbers

DATA MAPPING
For example purposes

INTERPETATION
Users explore and analyze the graph

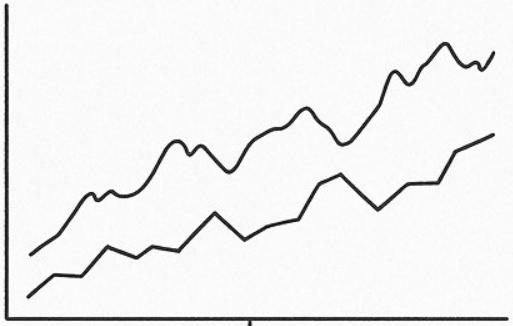
RENDERING
A line graph is generated

DATA PREPROCESSING
Data is cleaned and normalized

VISUAL ENCODING
Time on the x-axis cases on the y-axis

RENDERING
A line graph is generated

COVID-19 CASE TRENDS



1. Data Collection

•**Description**: The raw data is gathered from various sources like databases, experiments, surveys, or logs.

•**Example**: Collecting population statistics from a government census.

2. Data Processing

•**Description**: The raw data is cleaned, filtered, and structured to be usable.

•**Tasks**: Handling missing values, removing outliers, normalization.

•**Example**: Converting survey results into numerical form.

3. Data Analysis

•**Description**: Analytical techniques are used to extract patterns, trends, and insights from data.

•**Tools**: Statistical tools, machine learning models, etc.

•**Example**: Analyzing sales data to identify peak shopping periods.

4. Visual Representation

•**Description**: Data is displayed using graphs, charts, and infographics to make interpretation easier.

•**Common Formats**:

- **Bar Chart** – categorical comparison
- **Line Chart** – trend over time
- **Pie Chart** – percentage distribution
- **Scatter Plot** – correlation between variables

5. Visual Perception

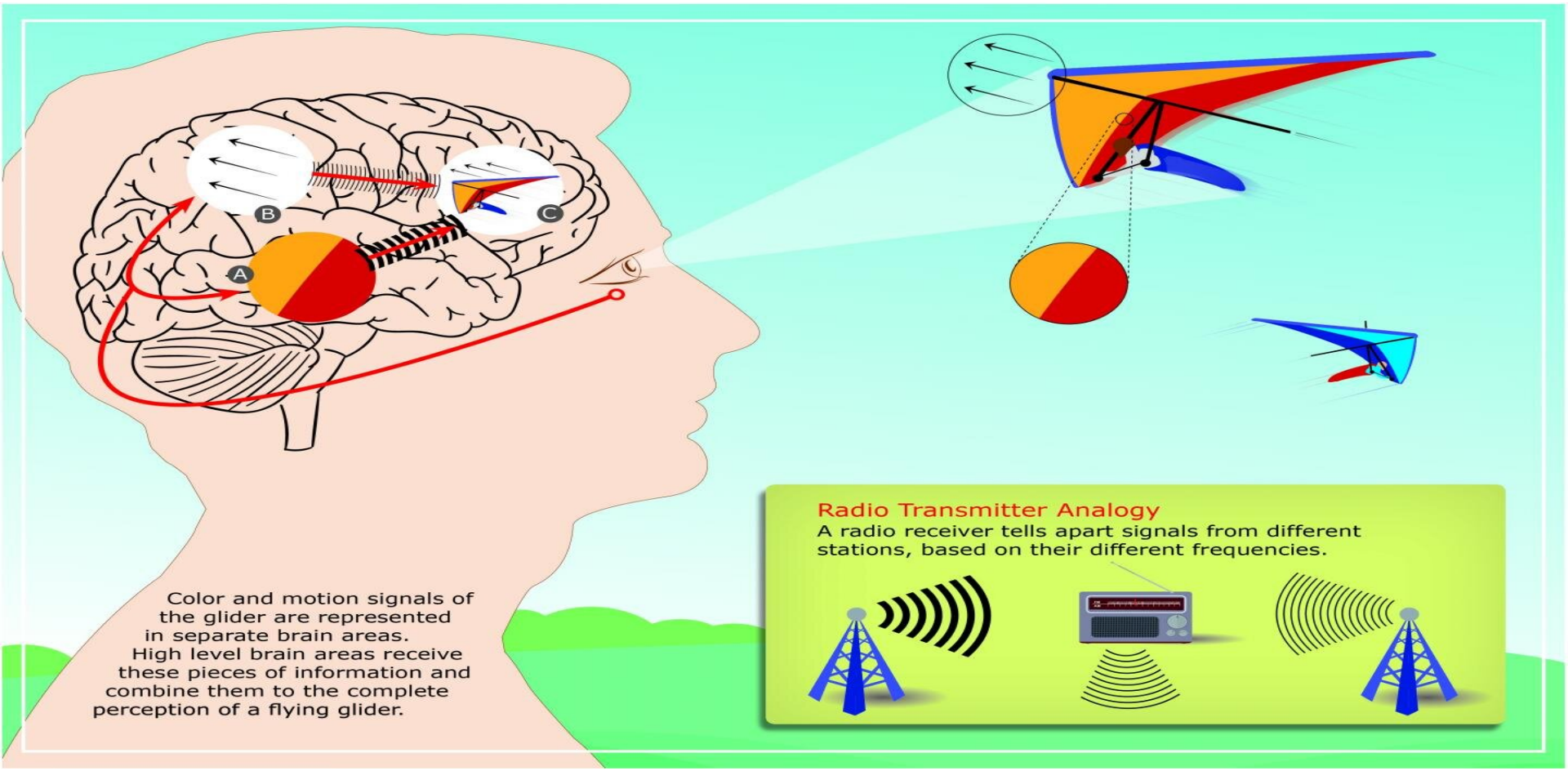
•**Description**: How users perceive, interpret, and derive meaning from visualized data.

•**Key Factors**:

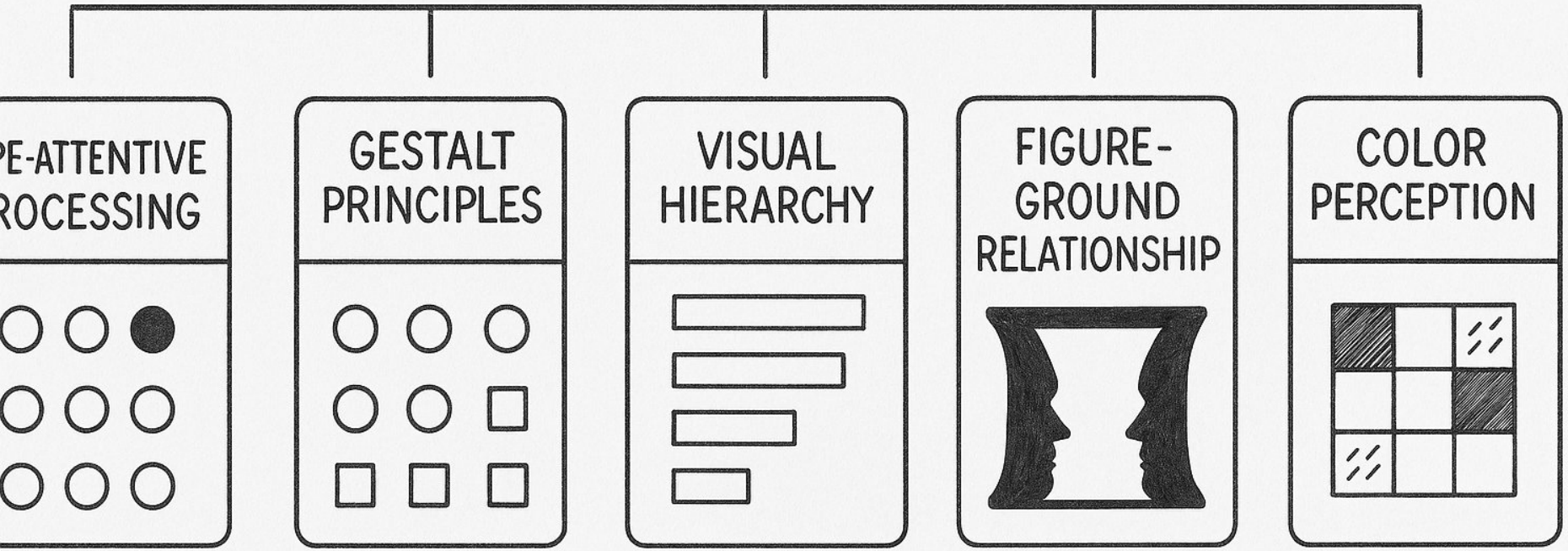
- Gestalt principles (proximity, similarity, continuity)
- Color usage
- Label clarity
- Chart simplicity

Visual Perception

- • Visuals are processed faster than text
- • Key factors: color, size, motion, proximity
- • Helps with faster recognition and insight



VISUAL PERCEPTION



Visual perception is the process by which our brain interprets and makes sense of visual information from the environment, primarily through our eyes.
In the context of **data visualization**, understanding visual perception is essential for designing clear, effective, and easily interpretable visuals.

Key Concepts in Visual Perception for Data Visualization:

1.Pre-attentive Processing:

1. Our brain can quickly recognize certain visual features **without conscious effort**.
2. Examples: color, orientation, size, shape, motion, and position.
3. ✔ Use these features to highlight important data instantly.

2.Gestalt Principles:

1. How people naturally group visual elements.
2. Important rules:
    1. **Proximity**: Items close together are seen as a group.
    2. **Similarity**: Similar items (color, shape) are grouped.
    3. **Continuity**: The eye follows smooth lines and paths.
    4. **Closure**: We fill in missing information to see complete shapes.
    5. Figure-Ground

1. **Visual Hierarchy**:
    1. Organizing elements to guide the viewer's attention in a logical order.
    2. Achieved through **size, contrast, positioning, and alignment**.
2. **Figure-Ground Relationship**:
    1. Differentiating the main subject (figure) from the background (ground).
    2. Clear separation ensures viewers know what to focus on.
3. **Color Perception**:
    1. Colors carry emotional and cultural meanings.
    2. Ensure good **contrast** for readability.
    3. Beware of **color blindness**; avoid red-green combinations without alternatives.
4. **Cognitive Load**:
    1. Avoid overloading the viewer's brain with too much info.
    2. Use **simplified and minimal designs** to enhance comprehension.

Gestalt Principles

Gestalt principles are foundational psychological concepts used in design and data visualization. They explain how humans tend to organize visual elements into groups or unified wholes when certain principles are applied. Here's a breakdown of the key Gestalt principles shown in your image and their detailed meanings:

- • Proximity – Grouping by closeness
- • Similarity – Grouping by visual similarity
- • Closure – Completing missing shapes
- • Continuity – Following lines
- • Figure-Ground – Focus vs. background

Gestalt psychology studies how people naturally organize visual information into meaningful wholes. Instead of seeing isolated marks, our brains **group** things using simple rules.
These rules are incredibly useful for data visualization and interface design because they let you guide attention, reduce clutter, and make relationships obvious at a glance.

1) Proximity (near things belong together)
What it is: Elements placed close to each other are perceived as a group.
Why it works: The visual system favors spatial efficiency—distance implies separation.
How to use it:
•Put labels closer to the marks they describe than to anything else.
•Cluster related filters or KPIs; add whitespace between unrelated sections.
•Use tight spacing within a legend group, and larger gaps between groups.
Watch out: Overcrowding ruins readability—balance tight grouping with legible spacing.



KPI (Key Performance Indicator) is a measurable value that shows how effectively an individual, team, or organization is achieving specific objectives.
It's like a **scoreboard** for performance — KPIs help track progress toward goals and highlight areas that need improvement.

Key Points:

- **Key** → Focuses on the most important metrics for success.
- **Performance** → Measures progress toward goals.
- **Indicator** → Provides a clear sign of whether you're on track or off track.

Examples:

- **Business:** Monthly sales revenue, customer satisfaction score (CSAT)
- **Website:** Conversion rate, bounce rate
- **Health:** Steps per day, calories burned

2) Similarity (alike things belong together)

What it is: Similar color, shape, size, or orientation implies membership in the same category.

Why it works: The brain looks for repeating patterns as signals of structure.

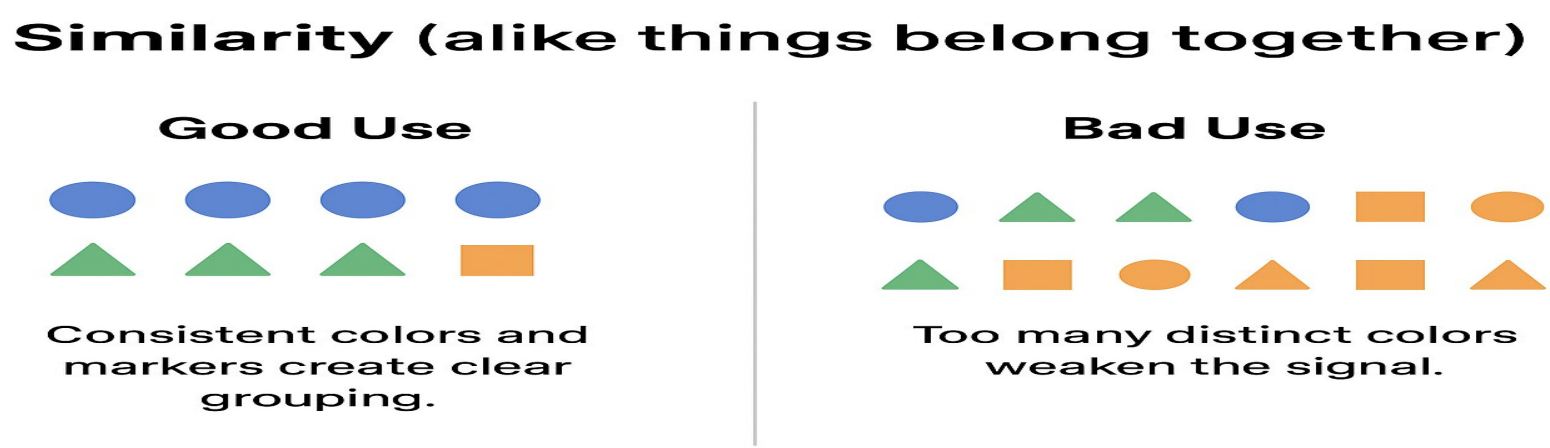
How to use it:

•Use consistent colors for the same category across all charts.

•Encode the same concept with the same marker (e.g., triangles for forecasts).

•Make “current year” lines share color/style across visuals.

Watch out: Using too many distinct colors weakens the signal; keep the palette small and purposeful



3) Common Region / Enclosure (things in the same container belong together)

What it is: Elements within a bounded region (box, card, shaded panel) are seen as a group.

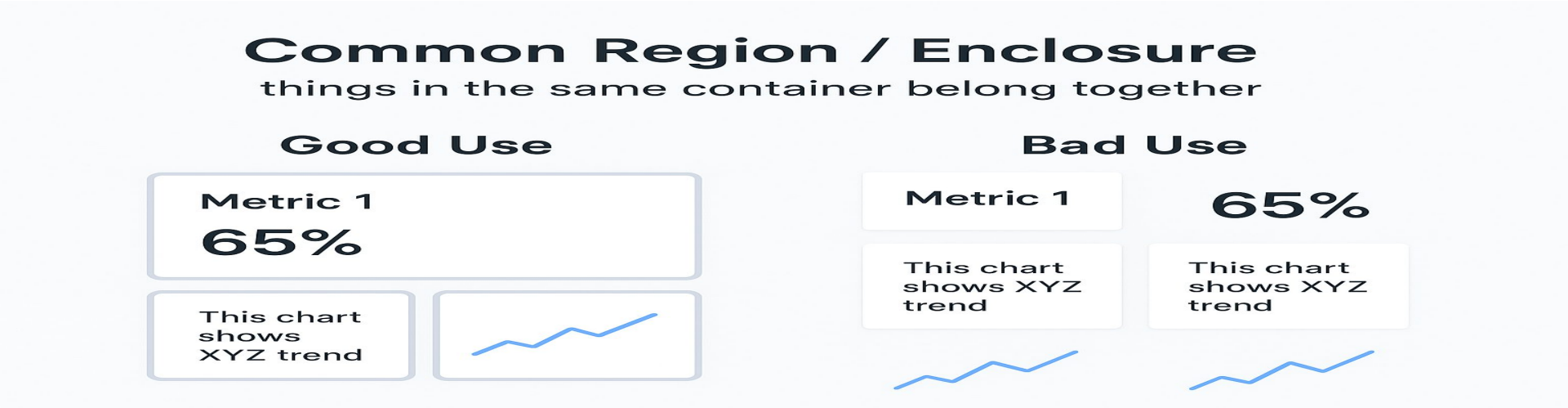
Why it works: Boundaries act like “visual fences.”

How to use it:

•Place related metrics inside a card; separate cards for different themes.

•Use subtle panel backgrounds to group a chart with its explanatory text.

Watch out: Over-boxing everything creates noise. Use enclosures sparingly.



4) Connectedness / Links (connected things belong together)
What it is: If items are joined by lines/edges, we see them as related—stronger than proximity/similarity.
Why it works: The eye follows connections as causal or structural relations.
How to use it:
•Lines connecting a point to its label (leader lines) when proximity isn't possible.
•Flow diagrams (Sankey, network graphs) to show relationships explicitly.
Watch out: Too many connectors = spaghetti. Prefer proximity or enclosure first.

5) Good Continuation (we follow smooth paths)
What it is: The eye prefers continuous lines/curves over abrupt changes.
Why it works: The visual system predicts smooth trajectories.
How to use it:
•Choose line charts for time trends; avoid unnecessary breaks.
•Align axes, edges, and baselines across panels so scanning is smooth.
•Sort bars to form a clear ascending/descending “path.”
Watch out: Misaligned gridlines, ragged labels, or broken axes interrupt flow.

6) Closure (we complete incomplete shapes)
What it is: The brain fills gaps to perceive whole forms.
Why it works: We prefer complete, stable shapes (good form).
How to use it:
•Minimalist icons/logos or sparklines can omit detail but remain legible.
•Imply boundaries with partial frames to reduce ink without losing grouping.
Watch out: Don’t remove so much that novices can’t reconstruct the shape.

7) Figure–Ground (separate foreground from background)
What it is: We distinguish a focal "figure" from a receding "ground."
Why it works: Contrast and focus allow quick object recognition.
How to use it:
•High contrast for key data; low contrast (muted gray) for context.
•Use white space to isolate important numbers (big number tiles).
•Apply soft backgrounds to separate sections without heavy borders.
Watch out: Poor contrast (e.g., light gray text on white) destroys legibility.

8) Symmetry & Balance (balanced forms feel unified)
What it is: Symmetric arrangements are perceived as coherent wholes.
Why it works: Symmetry reduces mental effort in parsing layout.
How to use it:
•Keep dashboards grid-aligned; use consistent margins and card sizes.
•Mirror layouts for comparable panels to encourage quick comparison.
Watch out: Perfect symmetry can feel static—use asymmetry to highlight a focal panel.

9) Common Fate / Synchrony (moving/behaving together = group)
What it is: Elements that move or change together are seen as related.
Why it works: The brain treats synchronized change as a shared cause.
How to use it (even without animation):
•Highlight multiple related marks at once on hover/brush.
•Animate filters so dependent charts update together.
Watch out: Gratuitous animation distracts; keep transitions purposeful and brief.

10) Prägnanz (Good Form/Simplicity)
What it is: We prefer the simplest, most stable interpretation of a scene.
Why it works: Simplicity minimizes cognitive load.
How to use it:
•Prefer simple chart types; avoid 3D, heavy gradients, stacked encodings.
•Reduce non-data ink: extra gridlines, outlines, drop shadows.
Watch out: Don’t oversimplify to the point of losing necessary detail.

11) Emergence & Invariance (recognize patterns despite changes)

What it is: We recognize wholes before parts, and across rotations/scale changes.

How to use it:

•Keep iconic shapes consistent so users recognize them across charts.

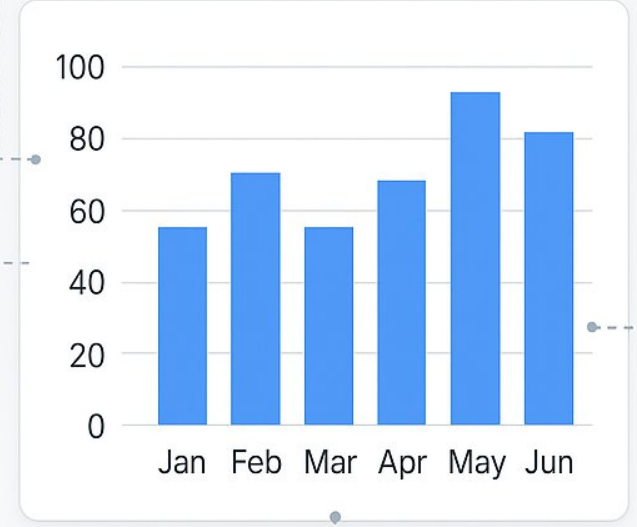
•Use small multiples: the overall pattern “emerges” across panels.

Gestalt Principles for Data Visualization

Proximity
Related iterns are grouped together

Similarity
Similar colors represent the same category

Closure
Complete shapes are percelved as whole



Continuity
Arrange elements to create smooth flow

Figure-Ground
Distinguish a focal element from the background

Common Fate
Related elements move together

Real time example:
Scenario:
A retail company has a **monthly sales dashboard** for its six product categories. The goal is to make it quick for managers to identify trends, compare categories, and spot outliers.

1.Proximity (Grouping by Nearness)
Example: In the dashboard, each product category's sales KPIs (total sales, growth rate, units sold) are placed close together in the same card.
Effect: Managers instantly know these numbers are related without reading labels.

2. Similarity (Grouping by Look)
Example: All "Electronics" category data is shown in **blue** across bar charts, pie charts, and line graphs.
Effect: Even if the charts are on different parts of the dashboard, the blue color signals they belong to the same category.

3. Continuity (Smooth Flow)
Example: A **line chart of monthly sales** is sorted in chronological order (Jan → Dec).
Effect: The viewer's eyes naturally follow the sales trend without confusion.

4. Closure (Completing Shapes)
Example: In a minimal design, bar outlines may be slightly open, but the brain still perceives the bar as a complete shape.
Effect: The viewer still understands the data without the need for heavy outlines.

5. Figure–Ground (Focus vs. Context)
Example: When a manager hovers over “May” sales data, that month’s bar is highlighted in bold color while others fade into light gray.
Effect: The hovered month stands out as the **figure**, and the rest becomes **background context**.

6. Common Fate (Moving Together)
Example: When a filter is applied (e.g., “Last Quarter”), **all related charts update at the same time**.
Effect: The synchronized change tells the user these elements are related to the same action.

Monthly Sales Dashboard

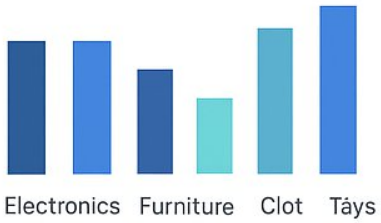
Total Sales
$120,000

Growth Rate
18%

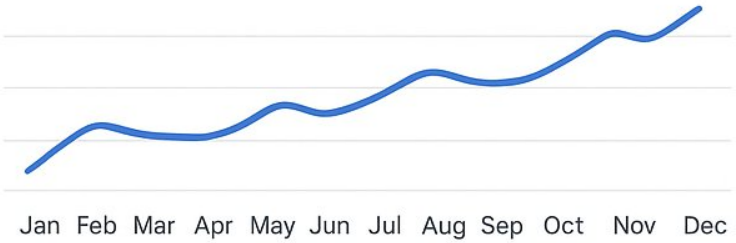
Units Sold
14,000



Sales by Category



Sales



Gestalt principles

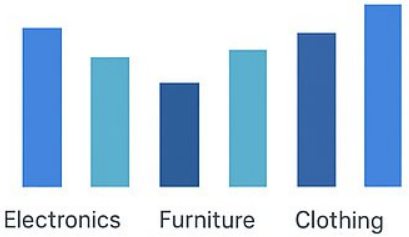
Total Sales
$120,00

Growth Rate
18%

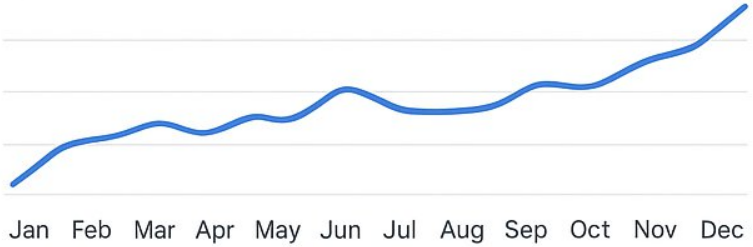
Units Sold
14,000



Sales b Category



Sales



Before (Without Gestalt Principles)

•Proximity issue:
KPI values (Total Sales, Growth Rate, Units Sold) are spaced far apart without visual grouping, so they don't feel related.

•Similarity inconsistency:
Inconsistent colors for the same category make it harder to connect data across charts.

•Continuity break:
Elements are not aligned well; the eye doesn't have a smooth flow to follow.

•Figure–Ground problem:
All elements are equally prominent; nothing stands out as the main focus.

•Label clarity:
Category names like "Clot" are incomplete and distracting.

After (With Gestalt Principles Applied)

•Proximity:
Related KPIs are grouped closer together and aligned, making them easy to scan.

•Similarity:
Each product category uses the same color across charts (e.g., Electronics is always blue).

•Continuity:
Elements are aligned horizontally, and spacing is consistent, so the viewer's eye naturally flows from KPIs → category chart → sales trend.

•Closure:
Even with minimal borders, the sections feel grouped because of alignment and spacing.

•Figure–Ground:
The dashboard title and KPIs stand out, guiding the viewer's attention to the most important metrics first.

Visual Representation of Data

Visual representation of data means converting raw data into graphical or pictorial formats (e.g., charts, graphs, maps, infographics) so that patterns, relationships, and trends are easier to understand

Data is displayed using graphs, charts, and infographics to make interpretation easier.

Purpose

- Make complex data **easier to interpret**.
- Highlight **patterns, correlations, and trends**.
- Communicate findings to both technical and non-technical audiences.
- Support **decision-making** with visual evidence.

- **Charts & Graphs**
- Bar Chart → Compare categories.
- Line Graph → Show trends over time.
- Pie Chart → Show proportions.
- Histogram → Show frequency distribution.
- **Tables**
- Exact values in structured form.
- **Maps**
- Geographic representation of data (e.g., heatmaps).
- **Dashboards**
- Combination of multiple visual elements to provide an overview.

•**Choose the right visual type** for the data.
•Use **consistent colors** and avoid overloading with too many hues.
•Keep labels **clear and readable**.
•Use **Gestalt principles** for clarity (proximity, similarity, continuity, figure-ground).
•Avoid **information overload** — focus on the story you want to tell.

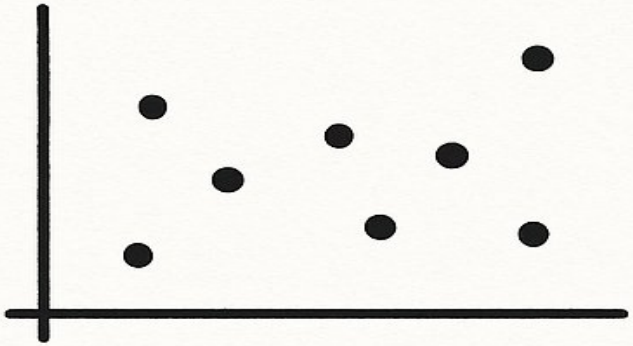
Example

•**Raw Data:** Sales figures for four product categories over 12 months.

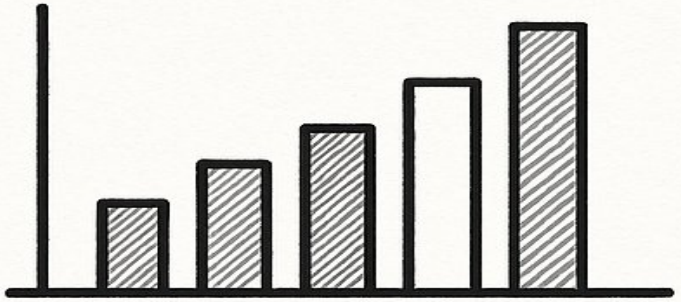
•**Visual Representation:**

- Line chart for monthly sales trend.
- Bar chart for category-wise performance.
- Pie chart for market share.

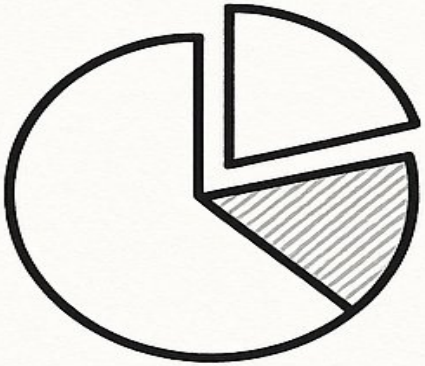
Visual Representation of Data



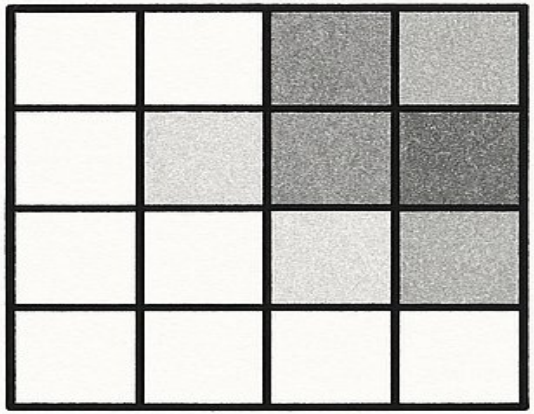
Scatter Plot



Bar Chart

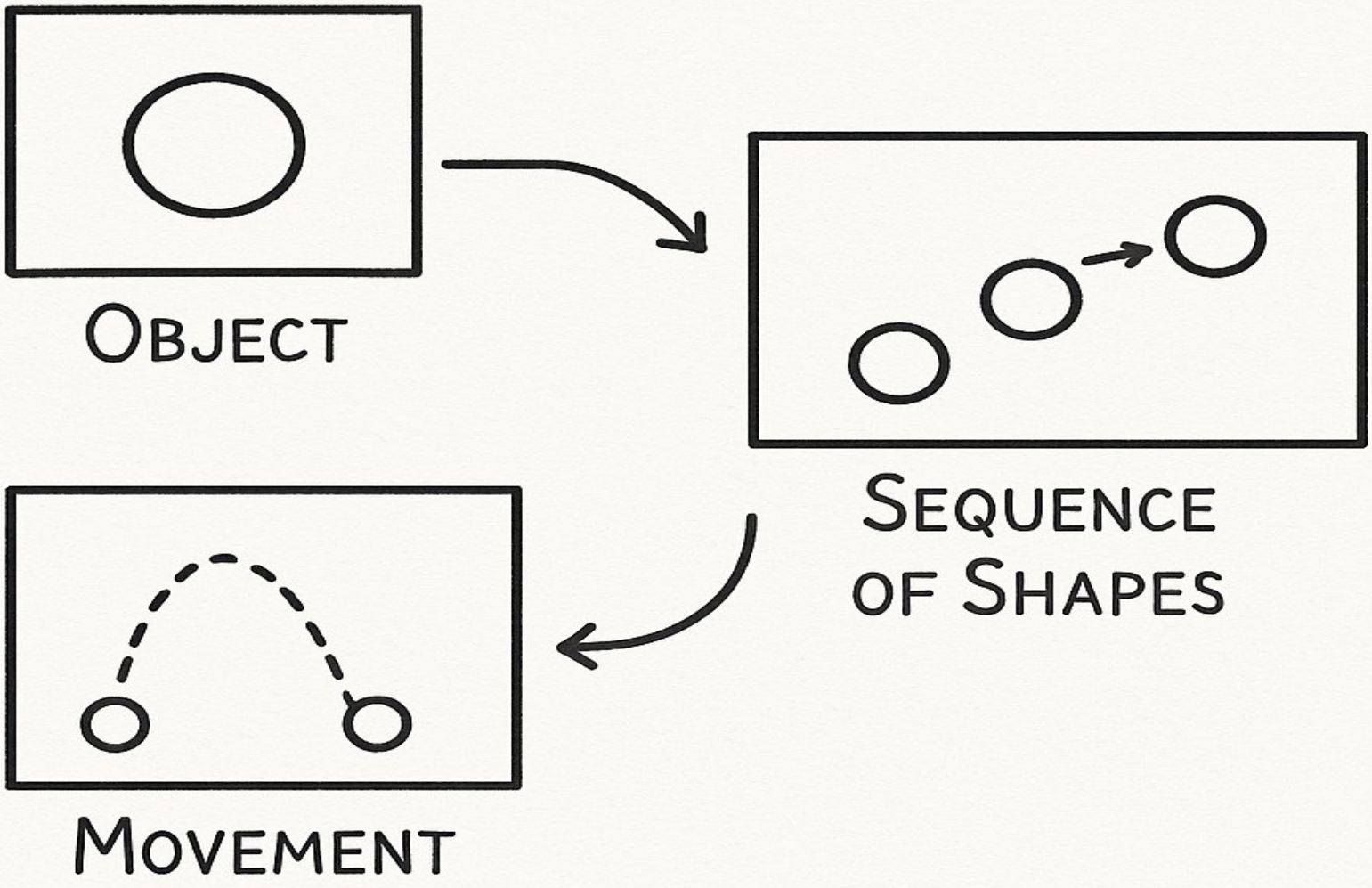


Pie Chart



Heatmap

Animations



Information Overload

Information overload occurs when the amount of information presented is so large or complex that it becomes difficult to process, understand, or make decisions.

Causes

1. **Too much data at once** – excessive charts, tables, or text.
2. **Poor visual design** – cluttered layouts, inconsistent colors, tiny fonts.
3. **Lack of hierarchy** – all elements given equal weight, no emphasis.
4. **Irrelevant details** – distracting users from key insights.
5. **No grouping or organization** – violating Gestalt principles.

Effects

- Reduces comprehension.
- Slows decision-making.
- Increases cognitive load (mental effort).
- Leads to ignoring important information.

Information Overload



- Prioritize key information
- Apply Gestalt principles
- Use progressive disclosure

Clear Visual Representation



- Use progre:sive disclosuere
- Keep visual design clean and minimal
- Use interactive filters

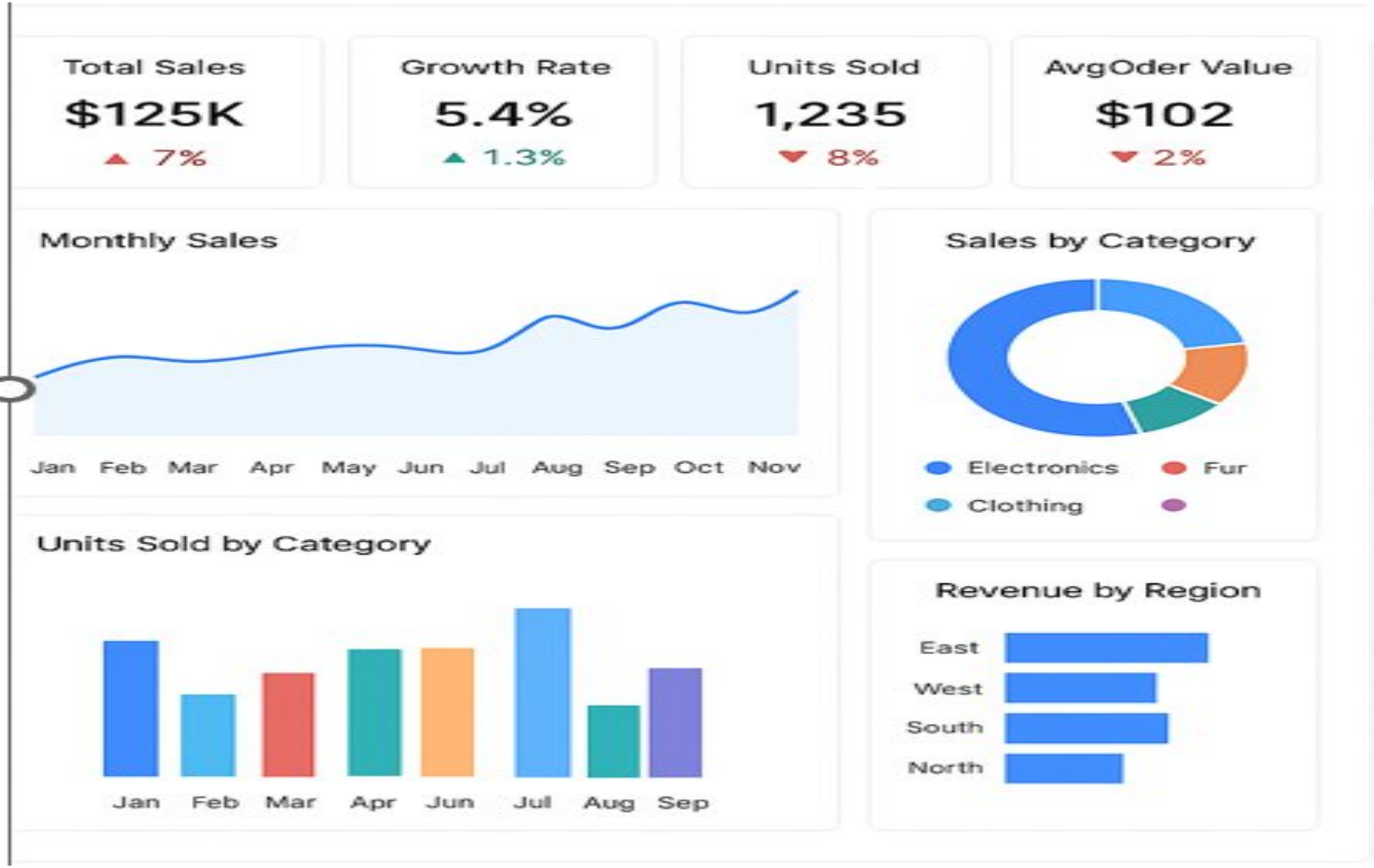
Example (Dashboard Context)

- **Bad Design (Overload):**
  - 15 charts squeezed into one screen.
  - All colors used randomly.
  - No clear titles or labels.
- **Good Design (Clear):**
  - Only key KPIs shown.
  - Logical grouping of related data.
  - Consistent color coding.
  - Adequate white space.

How to Avoid Information Overload

- **Prioritize** key information.
- Apply **Gestalt principles** (proximity, similarity, figure-ground).
- Use **progressive disclosure** – show details only when needed.
- Keep visual design **clean and minimal**.
- Use **interactive filters** to let users drill down.

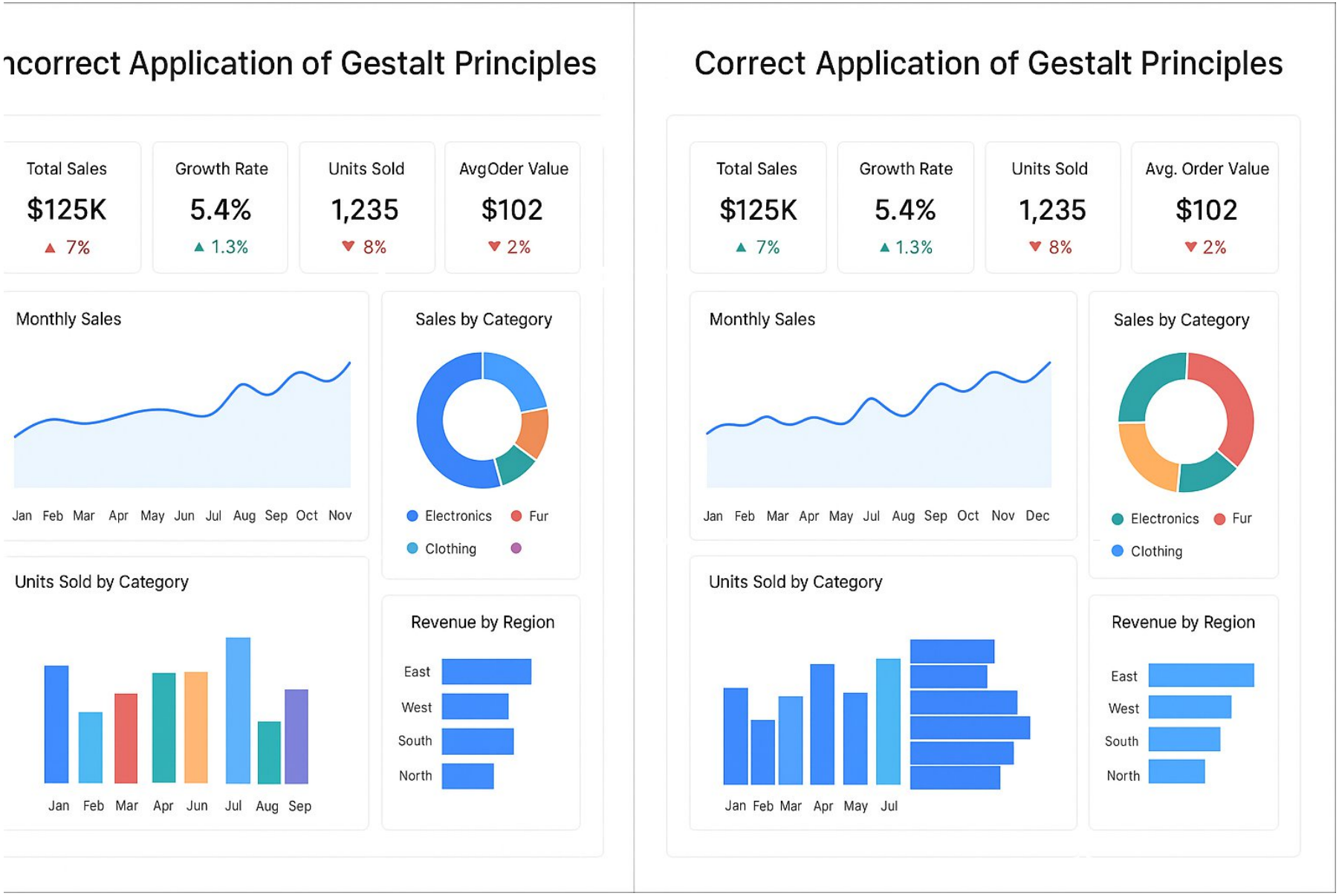
1. *Analyze a given dashboard and identify which Gestalt principles are applied incorrectly. Justify how this affects user understanding.*



- **Proximity violation:** Related KPIs are far apart, while unrelated elements are placed closer together.
- **Similarity inconsistency:** Same category uses different colors in different charts.
- **Figure–Ground failure:** No clear visual emphasis on important metrics; everything has the same color and weight.
- **Continuity break:** Misaligned charts disrupt the natural eye flow.

Justification – How this affects user understanding

- **Proximity violation** → Users may assume unrelated items are related, leading to misinterpretation of data groups.
- **Similarity inconsistency** → Users cannot easily track the same category across different visuals, increasing confusion.
- **Figure–Ground failure** → Key insights are lost in visual noise, making decision-making slower.
- **Continuity break** → Users' eyes jump randomly instead of following a logical order, breaking the storytelling flow.


ncorrect Application of Gestalt Principles
Total Sales
$125K
▲ 7%
Growth Rate
5.4%
▲ 1.3%
Units Sold
1,235
▼ 8%
AvgOder Value
$102
▼ 2%
Monthly Sales
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov
Sales by Category
Electronics
Fur
Clothing
Units Sold by Category
Jan Feb Mar Apr Jun Jul Aug Sep
Revenue by Region
East
West
South
North
Correct Application of Gestalt Principles
Total Sales
$125K
▲ 7%
Growth Rate
5.4%
▲ 1.3%
Units Sold
1,235
▼ 8%
Avg. Order Value
$102
▼ 2%
Monthly Sales
Jan Feb Mar Apr May Jul Aug Sep Oct Nov Dec
Sales by Category
Electronics
Fur
Clothing
Units Sold by Category
Jan Feb Mar Apr May Jul
Revenue by Region
East
West
South
North

Conclusion

- • Visualization bridges data and insight
- • Combines perception, design, and cognition
- • Clear visuals prevent overload and support decisions

References

- • Ward, Grinstein, Keim. Interactive Data Visualization
- • Tufte, Edward. Visual Display of Quantitative Information
- • Other academic/online sources