Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods

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Article introduction

Graphical Perception : Theory, Experimentation and Application to the Development of Graphical Methods - 1984

Written by William S. Cleveland and Robert McGill.

Statisticians at AT&T Bell Laboratories at time.

Article introduction

William S. Cleveland

Graduated at Princeton
Thesis at Yale University

Worked in statistics on local regression / visualization
Defined and formalized data science as we know it today.

Now professor of Statistics at Purdue University

Article introduction

Robert McGill

No information on his identity / his current job.

Worked along **William S. Cleveland** on several papers (16) about Data Visualization.

Context & motivation

Rise of plots and visualization in the society

It lacks evidences and theoretical proofs

Cleveland and **McGill** want to create a base for this domain.

Theory

The 10 representations of data

Color is not represented but belongs to those representations.

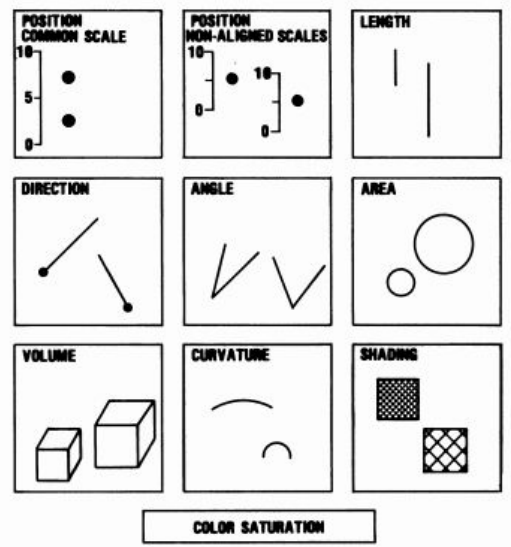


Figure 1. Elementary perceptual tasks.

Theory

Ranking representations :

Previous studies stated : *Length* > *Area* > *Volume.*

We can't consider color or shading due to their nature.

They chose accuracy metric over human perception.

Theory

Enumeration of plots and their use :

Several plot included, such as :

- Choropleth map, curve difference, scatter plot ..

They bet that :

- **Bar chart** : Position > length or area
- **Pie chart** : Angle > length or area
- **Cartesian Plot** (scatter) : slope > individual position

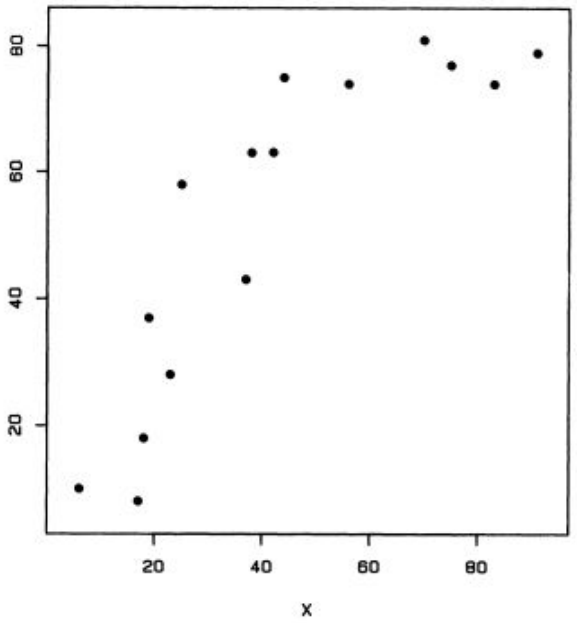


Figure 7. Cartesian graph.

Theory

Theoretical ranking :

They obtained the following ranking.

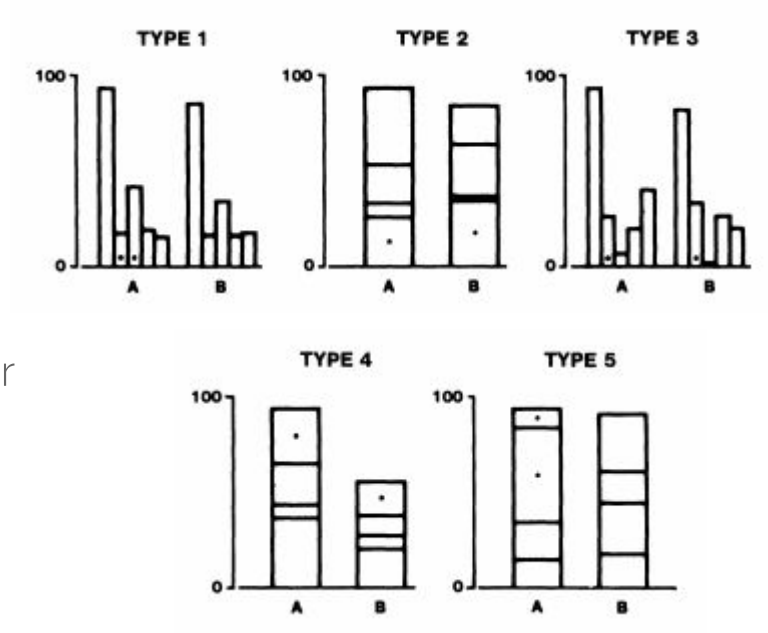
The following are the 10 elementary tasks in Figure 1, ordered from most to least accurate:

1. Position along a common scale
2. Positions along nonaligned scales
3. Length, direction, angle
4. Area
5. Volume, curvature
6. Shading, color saturation

Experiments

1 : Length against position

- **grouped** versus **stacked** bar charts
- Percentage of difference on dotted bar
- **55** candidates
- **50** pages of plots
- randomized order and distribution



Experiments

2 : angles against position

- **pie** against **bar** charts
- Percentage of difference on crossed area/bar to each other
- **51** candidates
- **20** pages of plots
- randomized order and distribution (sum to 100)

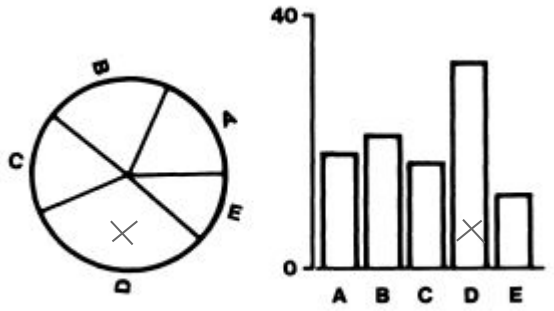


Figure 3. Graphs from position–angle experiment.

Results

Judgement 1

Position to length comparison
95% intervals

1.4 to 2.5 times more accurate

Judgement 2

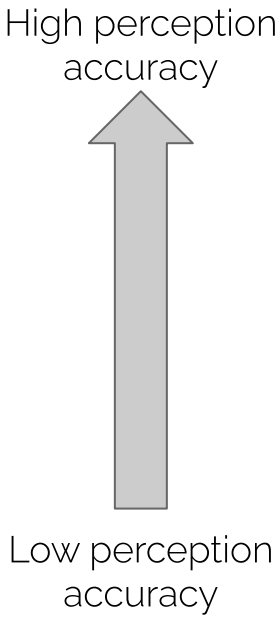
Position to angle comparison
95% intervals

1.96 times more accurate

Interpretation & consequences

Scale of perception accuracy :

- Position with common scale
- Position with non aligned scales
- Length, direction, angle
- Aera
- Volume, curvature
- Shading, saturation



Interpretations & consequences

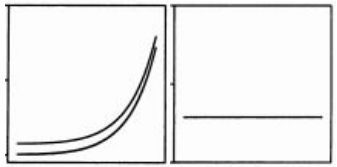
List of good practices :

- ~~Pie charts~~ → Bar charts / Scatter plot
- ~~Divided bar charts~~ → Bar charts / Scatter plot
- Use the same scale when possible

Interpretations & consequences

List of good practices :

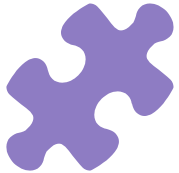
- Comparing two curves? Display their differences



- Try not to use shadings on statistical maps

- Use length size instead of area size for triple scatterplots

Interpretations & consequences



- Consequences on Data visualization :
  - A lot of DataViz tools implementation cite this article
  - Initiated a lot of perceptual accuracy and speed studies
- Today :
  - Immersive visualization solutions?