

# Visual Perception

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CMSC 205

Winter 2017

**What makes a good visualization?**

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# Tufte's graphical excellence

- ...is the well designed presentation of interesting data - a matter of substance, of statistics and of design.
- ...consists of complex data communicated with clarity, precision and efficiency.
- ...is that which gives to the viewer the greatest number of ideas in the shortest time with the least ink in the smallest space.
- ...is nearly always multivariate.
- ...requires telling the truth about the data.

# Ross Ihaka's three principles

- If the "story" is simple, keep it simple.
- If the "story" is complex, make it look simple.
- Tell the truth.

# Graphical perception

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The ability of viewers to interpret visual (graphical) encodings of information and thereby decode information in graphs.

# Which best encodes quantities?

Position

Length

Area

Volume

Value (Brightness)

Color

Hue

Orientation (Angle)

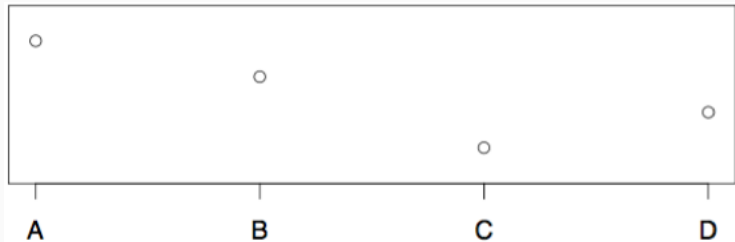
Shape

## Quick experiment

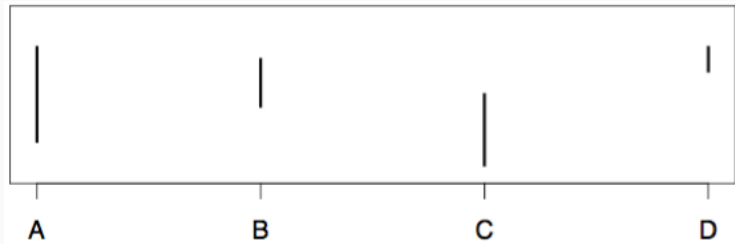
	A	B	C	D
Positions	1	?	?	?
Lengths	1	?	?	?
Angles	1	?	?	?
Areas	1	?	?	?



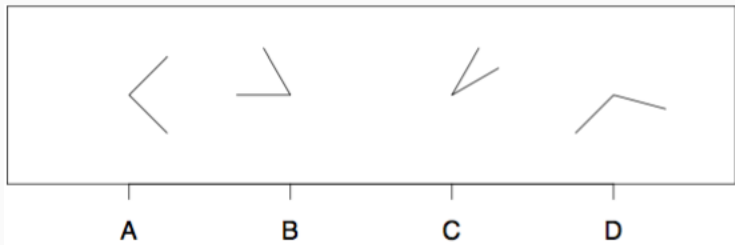
## Perceptual task: position, aligned



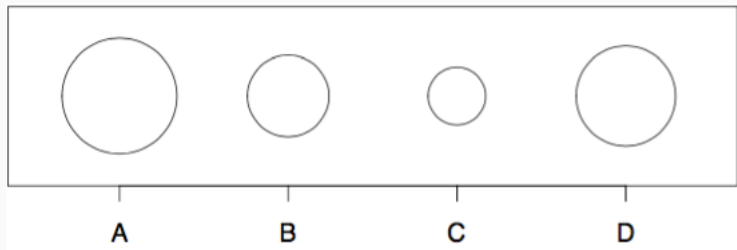
## Perceptual task: length



## Perceptual task: angle

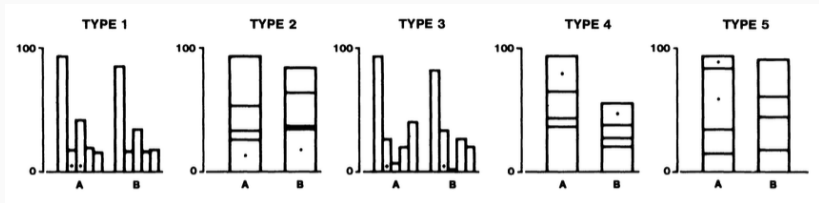


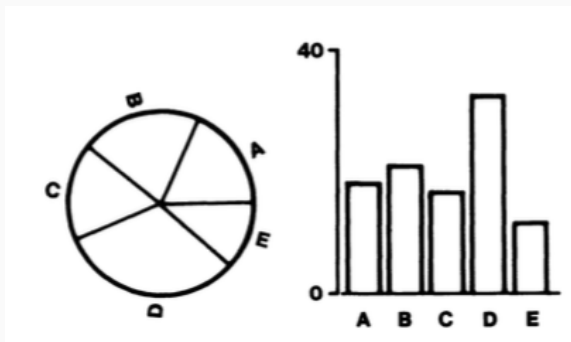
## Perceptual task: area

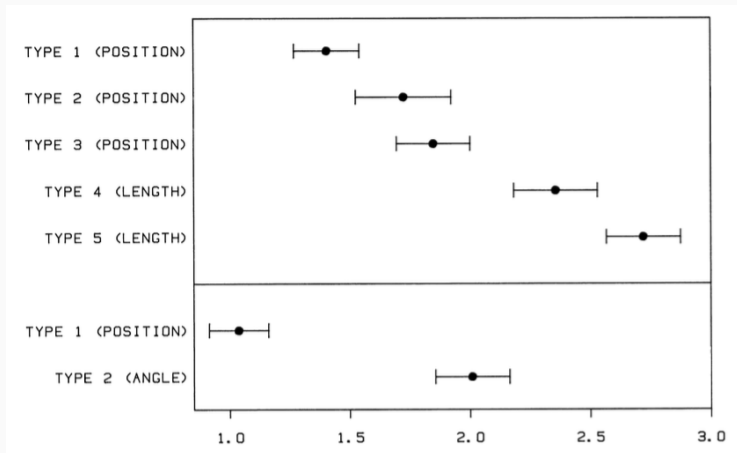


## Quick experiment

	A	B	C	D
Positions	1	$3/4$	$1/4$	$2/4$
Lengths	1	$2/4$	$3/4$	$1/4$
Angles	1	$2/3$	$1/3$	$4/3$
Areas	1	$2/4$	$1/4$	$3/4$









# Relative magnitude estimation (Cleveland & McGill, 1984)

Allows more  
accurate comparisons



2D position along common, aligned scale



2D position along common, but unaligned scales



Length



# Relative magnitude estimation (Cleveland & McGill, 1984)

Allows more  
generic comparisons

Slope



Angle



Area



Colour intensity



Volume



Colour hue



## Mackinlay's ranking of encodings

Quantitative	Ordinal	Nominal
Position	Position	Position
Length	Density (Val)	Color Hue
Angle	Color Sat	Texture
Slope	Color Hue	Connection
Area (Size)	Texture	Containment
Volume	Connection	Density (Val)
Density (Val)	Containment	Color Sat
Color Sat	Length	Shape
Color Hue	Angle	Length
Texture	Slope	Angle
Connection	Area (Size)	Slope
Containment	Volume	Area (Size)
Shape	Shape	Volume

- Show quantitative variables with position or length
- Bars encode length, start them at 0 — switch to dotplots to zoom in
- Avoid stacked bars (not aligned) — use dots/lines (aligned baselines) instead
- Avoid pie charts, area, and volume
- Choose and order hues sensibly (Color Brewer does this)
- Place things you want to compare close to each other

Tasks that can be performed on large multi-element displays in less than 200 to 250 milliseconds (msec) are considered preattentive.

## How many 6s

0	5	0	8	2	4	9	3	2	0	6	9	0	0	3	0	4	6	2	7
9	0	1	1	7	9	9	7	9	3	4	6	4	4	9	7	4	8	0	7
3	7	6	5	2	7	5	9	5	5	9	2	7	3	1	0	0	3	6	8
4	4	5	5	4	6	7	2	7	3	2	4	3	8	5	0	3	6	2	7
4	7	4	1	5	5	1	8	1	3	7	9	9	1	1	2	2	1	5	2

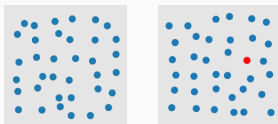
## How many 6s

0	5	0	8	2	4	9	3	2	0	6	9	0	0	3	0	4	6	2	7
9	0	1	1	7	9	9	7	9	3	4	6	4	4	9	7	4	8	0	7
3	7	6	5	2	7	5	9	5	5	9	2	7	3	1	0	0	3	6	8
4	4	5	5	4	6	7	2	7	3	2	4	3	8	5	0	3	6	2	7
4	7	4	1	5	5	1	8	1	3	7	9	9	1	1	2	2	1	5	2

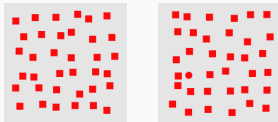
# Preattentive processing

<https://www.csc2.ncsu.edu/faculty/healey/PP/>

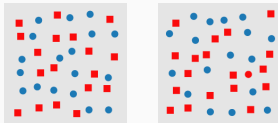
Pop-out: Color



Pop-out: Shape



Conjunction search

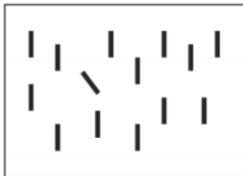




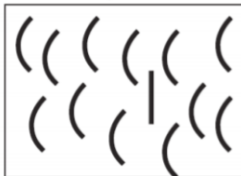
# Preattentive features

From *Information Visualization*, Ware

Orientation



Curved/straight



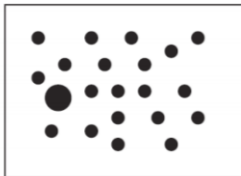
Shape



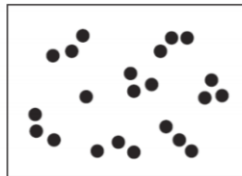
Shape



Size

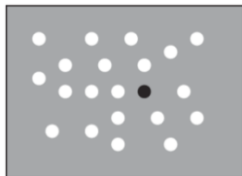


Number

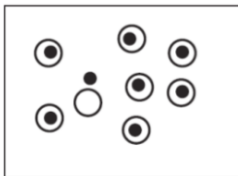


# Preattentive features

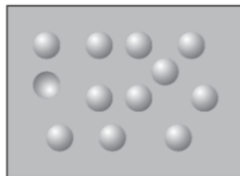
Gray/value



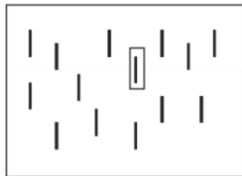
Enclosure



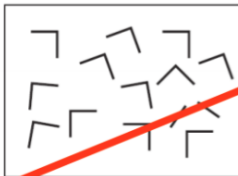
Convexity/concavity



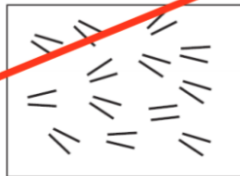
Addition



Juncture

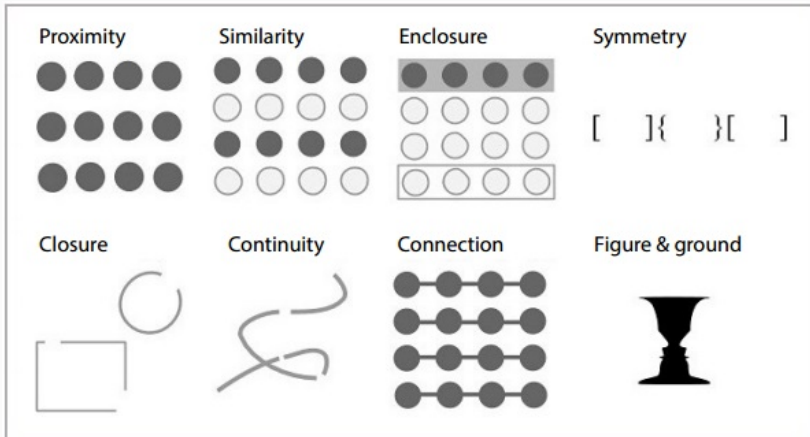


Parallelism



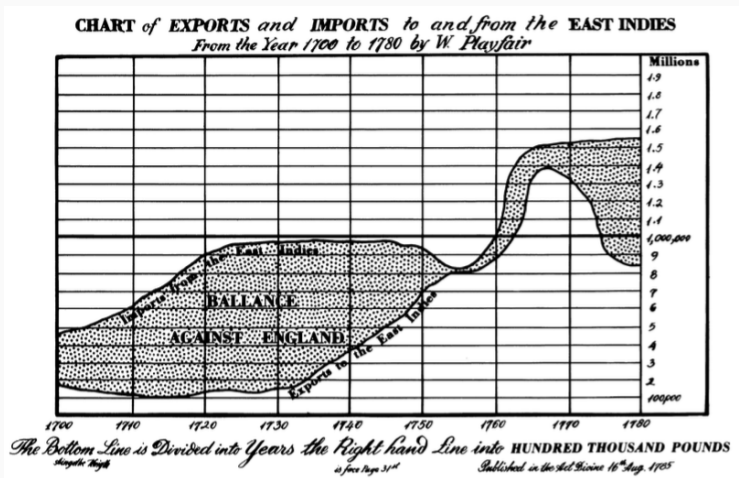
- Distinguish categorical groups by features like hue and shape
- Don't try to show too many groups on one plot; use small multiples to show more sub-groups
- If highlighting one group, use a preattentive attribute

- Gestalt = “pattern” in German
- How do we identify structure/pattern from individual elements?

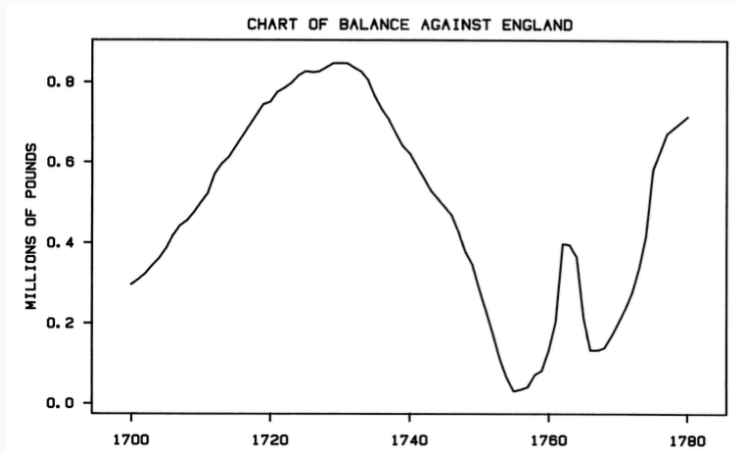


- Distinguish categorical groups by similarity, proximity, or enclosure
- Use proximity to structure your layout (arrange small multiples)
- Use connection to show groups on line chart, parallel coordinates chart, network graph, etc.
- To highlight one group, use gestalt principles such as enclosure or similarity

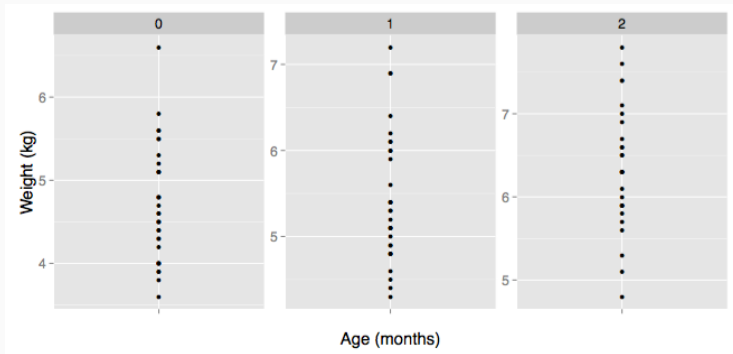
# Plot what you want to show



# Plot what you want to show

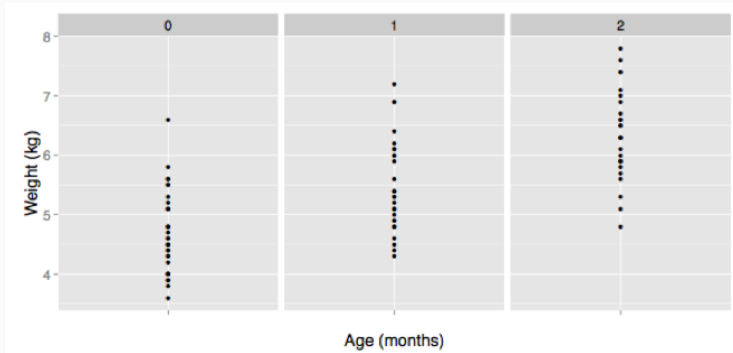


# Be consistent





# Be consistent



# Be consistent

## SUPREME COURT

*Three out of nine*



CONGRESS *104 out of 535*



## HOUSE OF REPRESENTATIVES

*84 women  
out of 435  
(19%)*



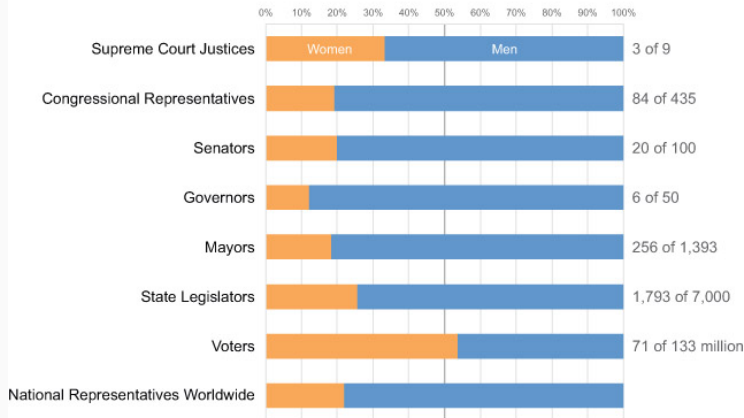
## SENATE

*20  
women  
out of  
100  
(20%)*



## Why we still need Women's Equality Day

95 years after women got the right to vote, the U.S. government is still only about 20% female, with lowest representation among governors and mayors.



Since 1995, the percentage of women in national legislatures has almost doubled worldwide, but still only 22% of all national elected representatives are female. Saudi Arabia just allowed women to register to vote in August. Vatican City still does not allow women to vote.

These slides were adapted from slides by

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- Jerzy Wiecezorek