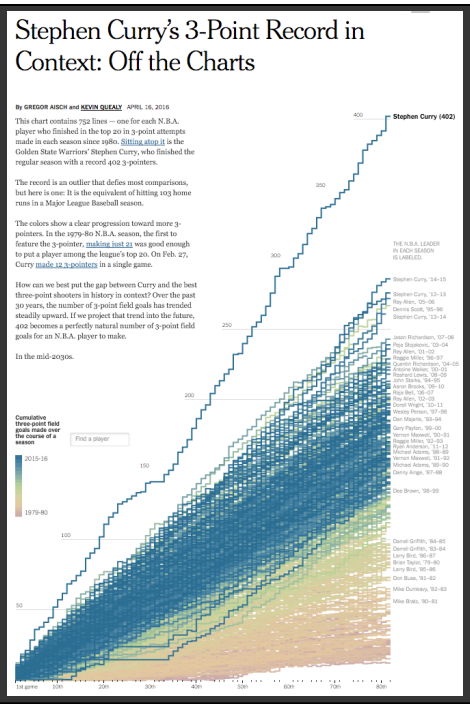
Interaction

Maneesh Agrawala

CS 448B: Visualization
Fall 2017



Stephen Curry's 3-Point Record in Context: Off the Charts

By GREGOR AISCH and KEVIN QUEALY APRIL 16, 2016

This chart contains 752 lines — one for each N.B.A. player who finished in the top 20 in 3-point attempts made in each season since 1980. Sitting atop it is the Golden State Warriors' Stephen Curry, who finished the regular season with a record 402 3-pointers.

The record is an outlier that defies most comparisons, but here is one: It is the equivalent of hitting 103 home runs in a Major League Baseball season.

The colors show a clear progression toward more 3-pointers. In the 1979-80 N.B.A. season, the first to feature the 3-pointer, making just 21 was good enough to put a player among the league's top 20. On Feb. 27, Curry made 12 3-pointers in a single game.

How can we best put the gap between Curry and the best three-point shooters in history in context? Over the past 30 years, the number of 3-point field goals has trended steadily upward. If we project that trend into the future, 402 becomes a perfectly natural number of 3-point field goals for an N.B.A. player to make.

In the mid-2030s.

Last Time: Perception

Just noticeable difference

JND (Weber's Law)

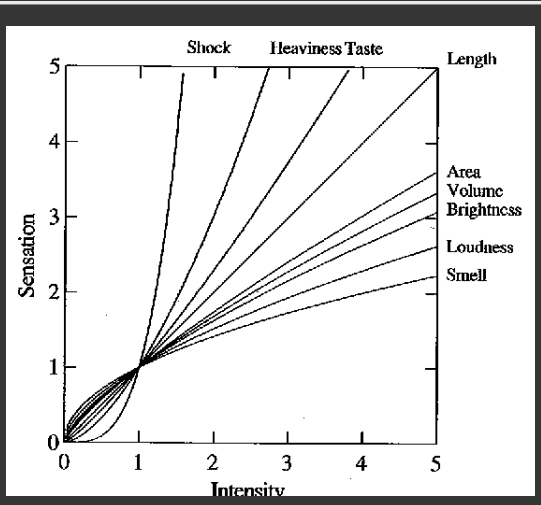
$$\Delta S = k\frac{\Delta I}{I}$$

- Ratios more important than magnitude
- Most continuous variations in stimuli are perceived in discrete steps

Steven's power law

$$S = I^p$$

p < 1 : underestimate
p > 1 : overestimate



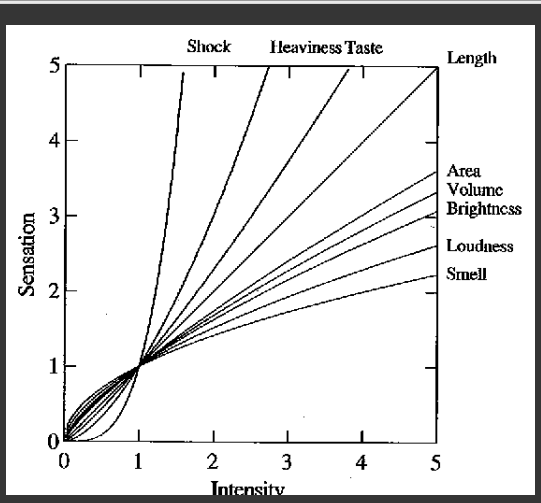
[graph from Wilkinson 99, based on Stevens 61]

Steven's power law

$$S = I^p$$

The law predicts *bias:* the deviation of population-averaged estimates from the true values.

It doesn't necessarily predict *error*! What if length averages to the true value but most estimates exhibit high deviation?



[graph from Wilkinson 99, based on Stevens 61]

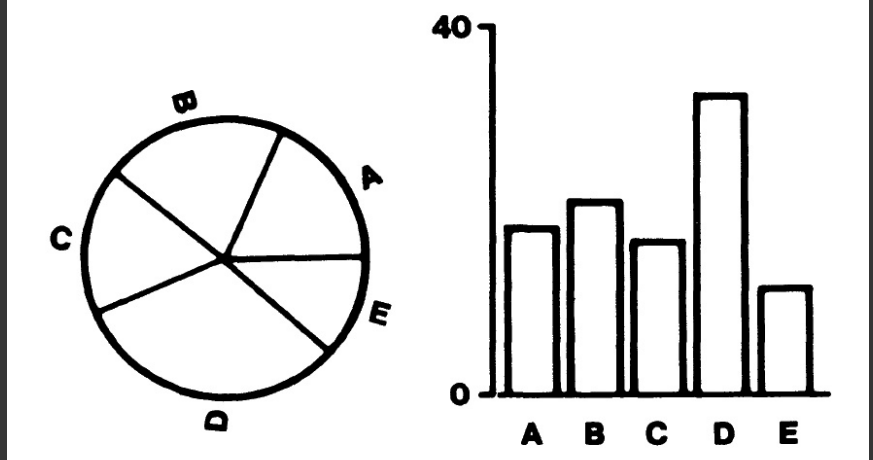


Figure 3. Graphs from position–angle experiment.

[Cleveland and McGill 84]

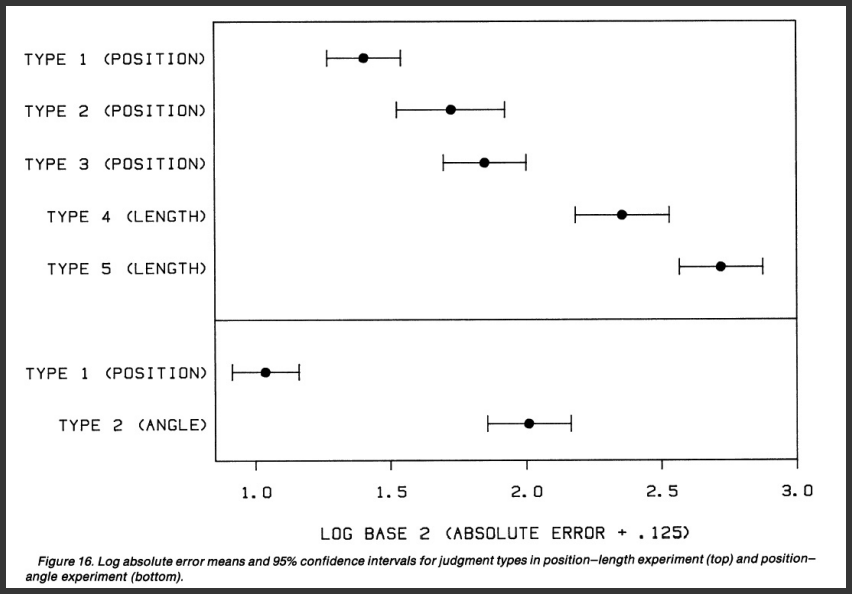


Figure 16. Log absolute error means and 95% confidence intervals for judgment types in position–length experiment (top) and position–angle experiment (bottom).

[Cleveland and McGill 84]

Relative magnitude estimation

Most accurate

Least accurate

Position (common) scale
Position (non-aligned) scale

Length

Slope

Angle

Area

Volume

Color hue-saturation-density

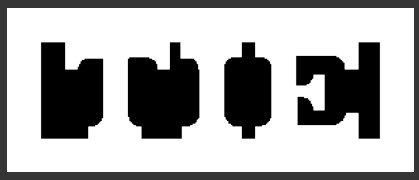
Gestalt

Principles

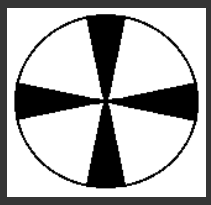
- figure/ground
- proximity
- similarity
- symmetry
- connectedness
- continuity
- closure
- common fate
- transparency

Figure/Ground

Ambiguous



Principle of surroundedness

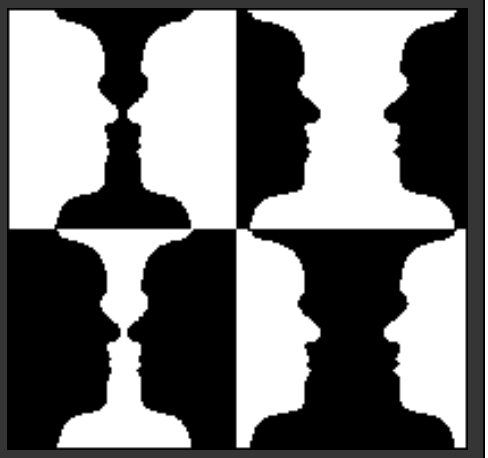


Principle of relative size

http://www.aber.ac.uk/media/Modules/MC10220/visper06.html

Figure/Ground

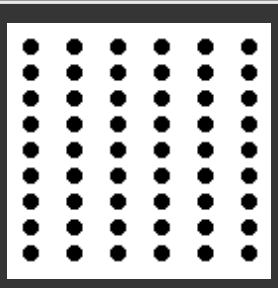
Ambiguous

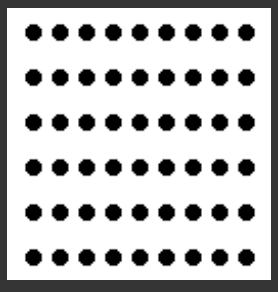


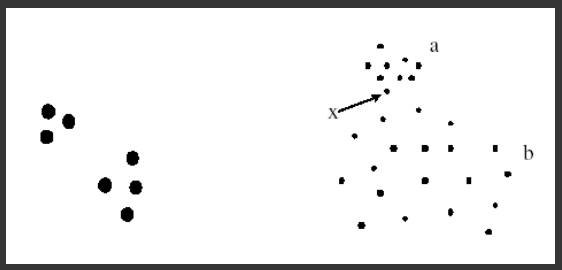
Unambiguous

http://www.aber.ac.uk/media/Modules/MC10220/visper06.html

Proximity

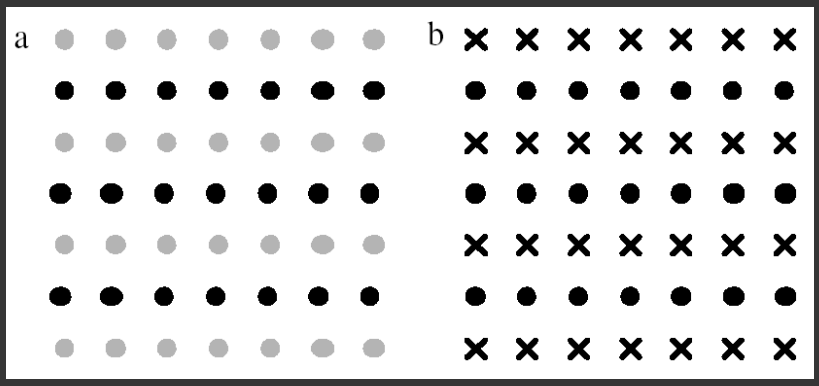






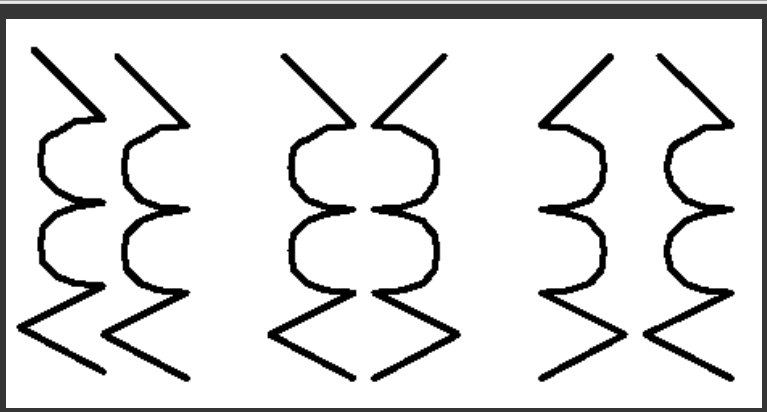
[Ware 00]

Similarity



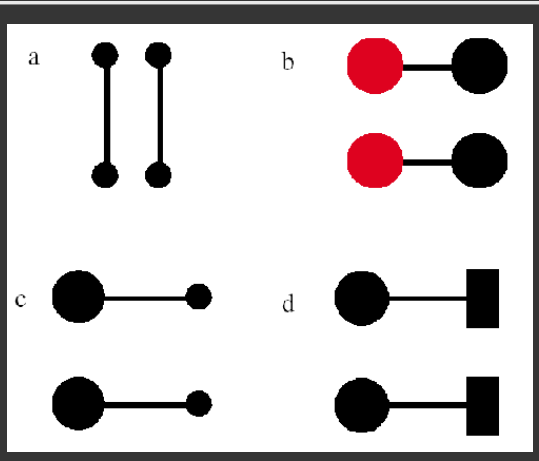
Rows dominate due to similarity [from Ware 04]

Symmetry



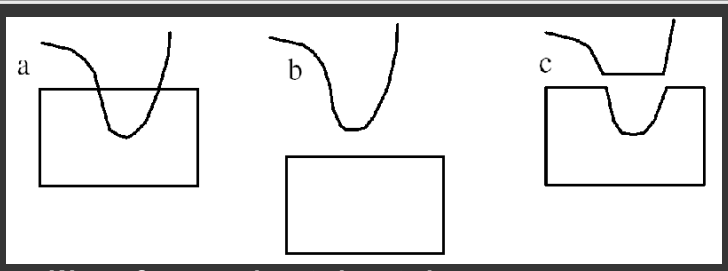
Bilateral symmetry gives strong sense of figure [from Ware 04]

Connectedness

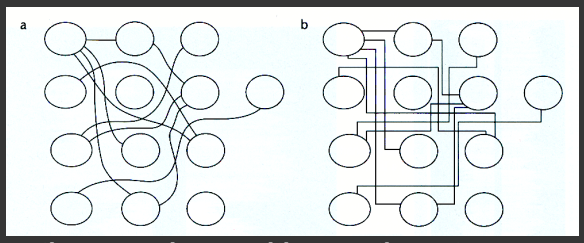


Connectedness overrules proximity, size, color shape [from Ware 04]

Continuity

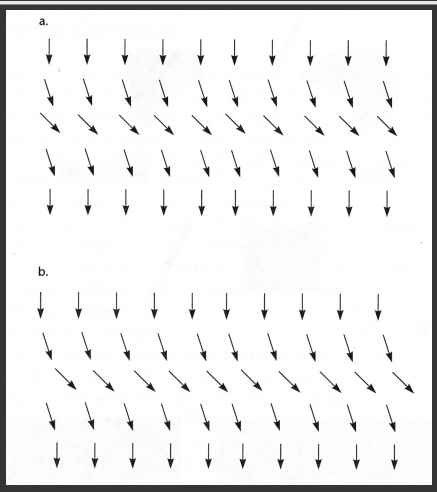


We prefer smooth not abrupt changes [from Ware 04]



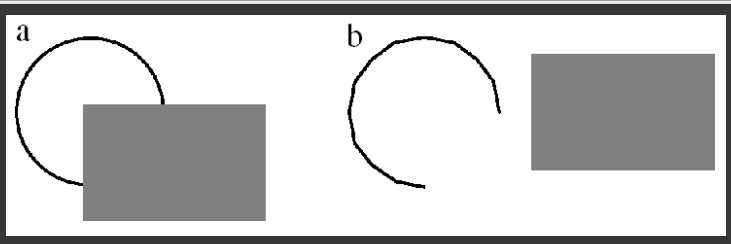
Connections are clearer with smooth contours [from Ware 04]

Continuity: Vector fields

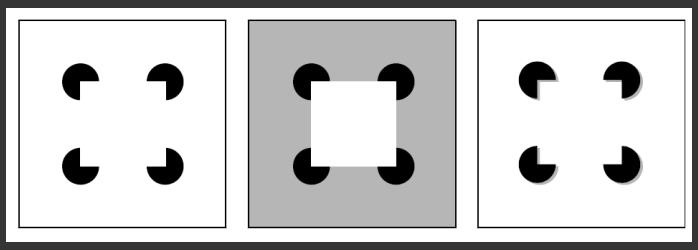


Prefer field that shows smooth continuous contours [from Ware 04]

Closure

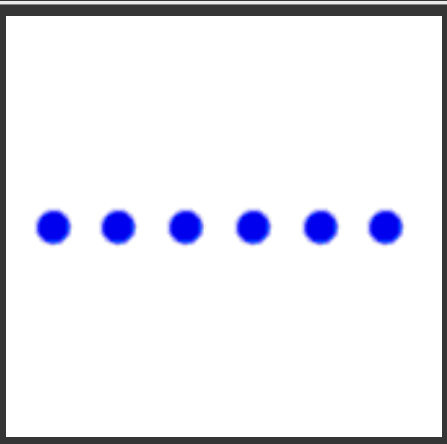


We see a circle behind a rectangle, not a broken circle [from Ware 04]



Illusory contours [from Durand 02]

Common fate



Dots moving together are grouped

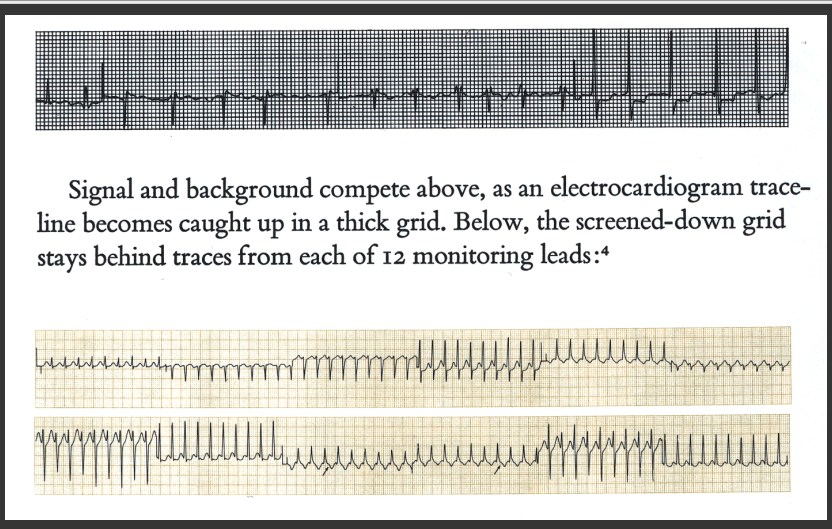
http://coe.sdsu.edu/eet/articles/visualperc1/start.htm

Transparency

Requires continuity and proper color correspondence [from Ware 04]

Layering and Small Multiples

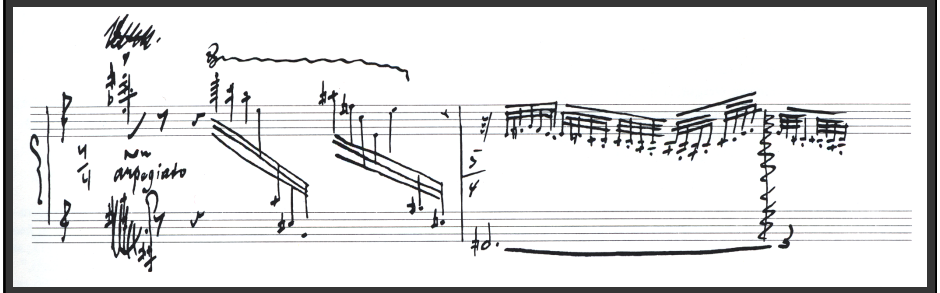
Layering: Gridlines



Signal and background compete above, as an electrocardiogram trace-line becomes caught up in a thick grid. Below, the screened-down grid stays behind traces from each of 12 monitoring leads:[4]

Electrocardiogram tracelines [from Tufte 90]

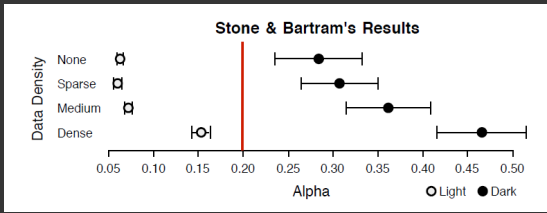
Layering: Gridlines



Stravinsky score [from Tufte 90]

Setting Gridline Contrast

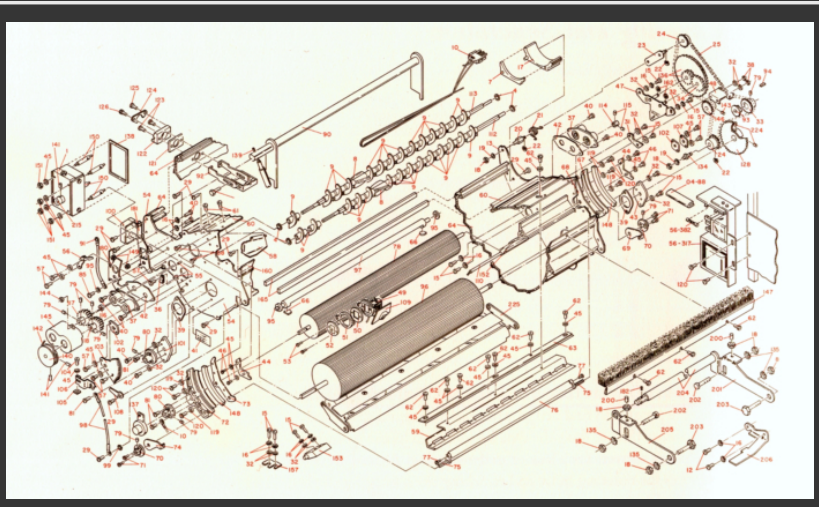
How light can gridlines be and remain visible?
How dark can gridlines be and not distract?



Safe setting: 20% Alpha

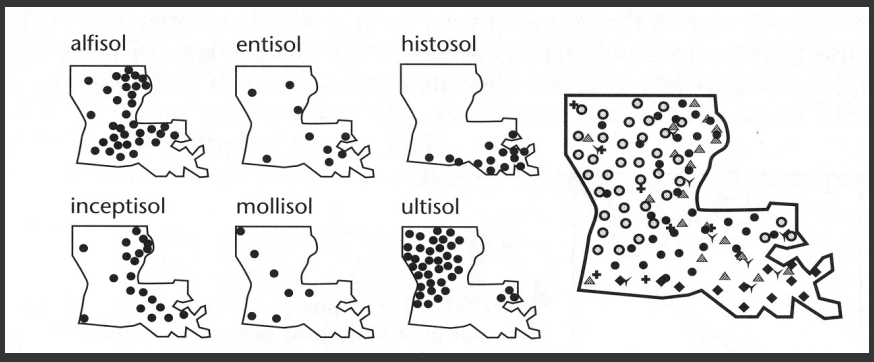
[Stone & Bartram 2009]

Layering: Color and line width



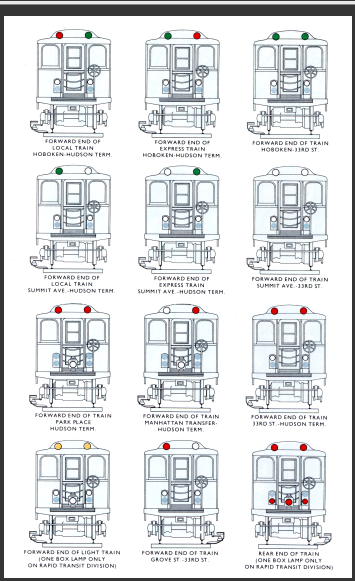
IBM Series III Copier [from Tufte 90]

Small multiples



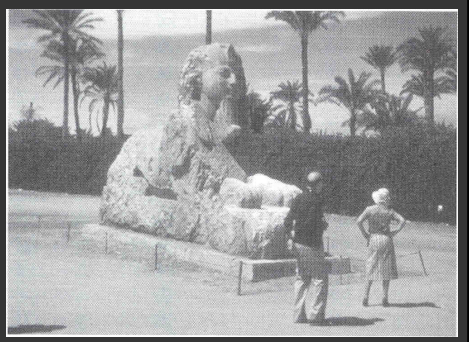
[Figure 2.11, p. 38, MacEachren 95]

Small multiples



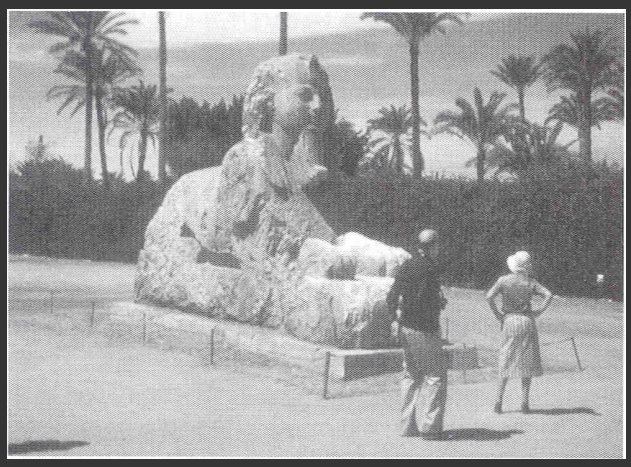
Operating trains. Redrawn by Tufte to emphasize colored lights. [fromTufte 90]

Change blindness

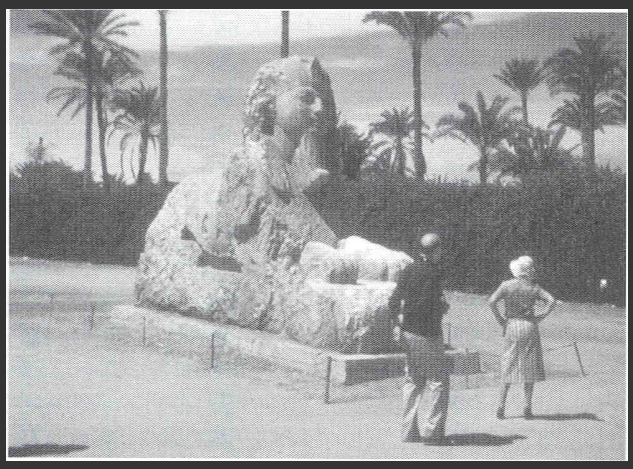


[Example from Palmer 99, originally due to Rock]

Change detection



Change detection



Rensink's demonstration

http://www.csc.ncsu.edu/faculty/healey/PP/index.html

Summary

Choosing effective visual encodings requires knowledge of visual perception

Visual features/attributes

- Individual attributes often preattentive
- Multiple attributes may be separable, often integral

Gestalt principles provide higher level design guidelines

We don't always see everything that is there

Announcements

Assignment 2: Exploratory Data Analysis

Use Tableau to formulate & answer questions

First steps

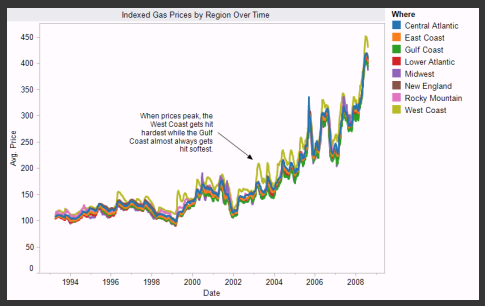
- Step 1: Pick a domain
- Step 2: Pose questions
- Step 3: Find data
- Iterate

Create visualizations

- Interact with data
- Question will evolve
- Tableau

Make notebook

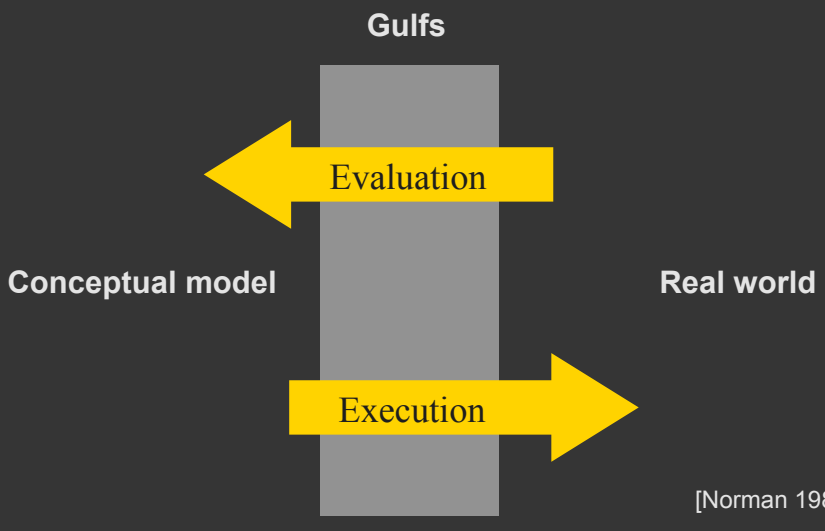
- Keep record of all steps you took to answer the questions



Due before class on Oct 16, 2017

Interaction

Gulfs of execution & evaluation



[Norman 1986]

Gulf of Execution

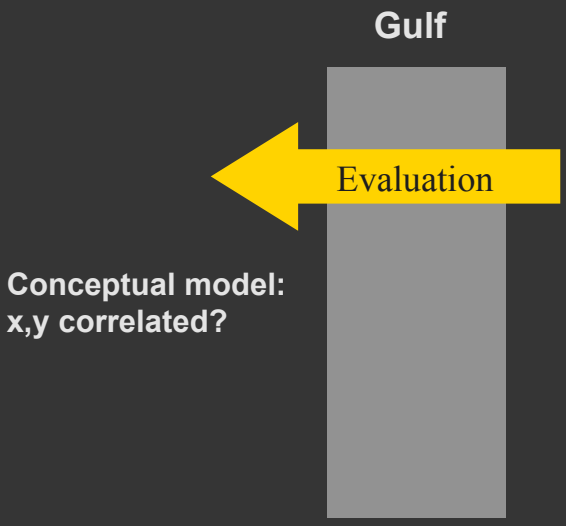
The difference between the user's intentions and the allowable actions.

Gulf of Evaluation

The amount of effort that the person must exert to interpret the state of the system and to determine how well the expectations and intentions have been met.

[Norman 1986]

Gulf of evaluation



X	Y
0.67	0.79
0.32	0.63
0.39	0.72
0.27	0.85
0.71	0.43
0.63	0.09
0.03	0.03
0.20	0.54
0.51	0.38
0.11	0.33
0.46	0.46

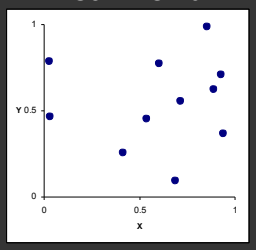
Gulf of evaluation

Gulf

Evaluation

Conceptual model:
x,y correlated?

Real world:



Gulf of evaluation

Gulf

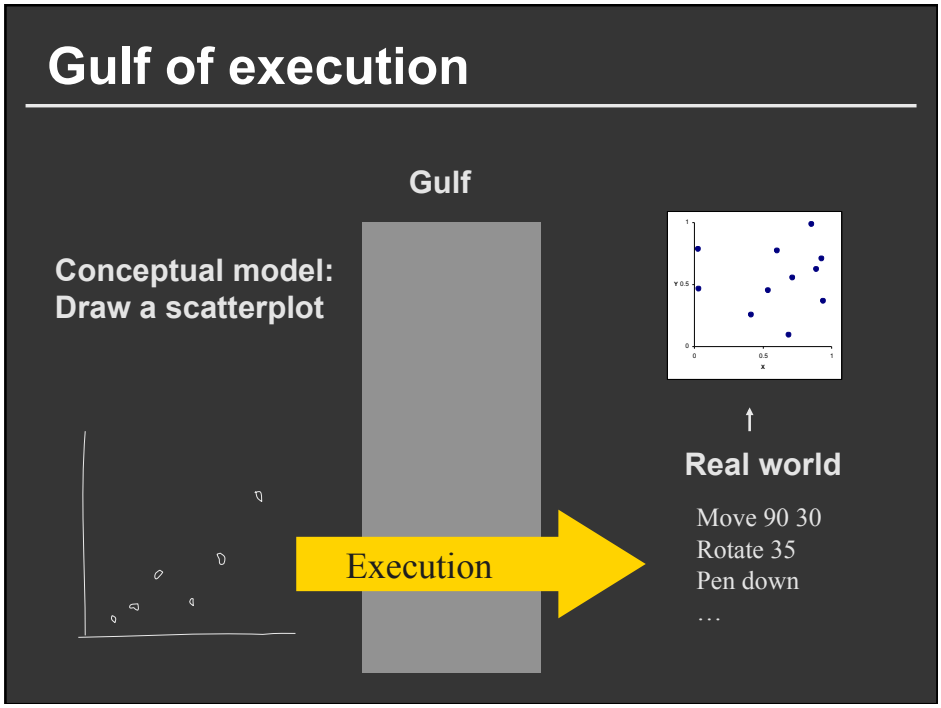
Evaluation

Conceptual model:
x,y correlated?

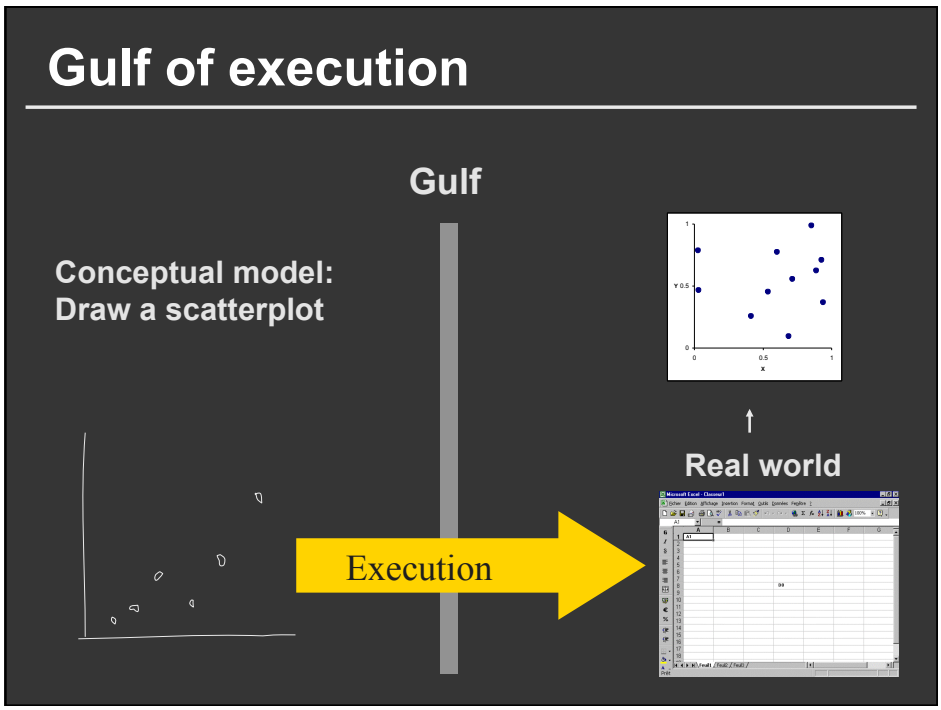
Real world:

$\rho = -.29$

Gulf of execution



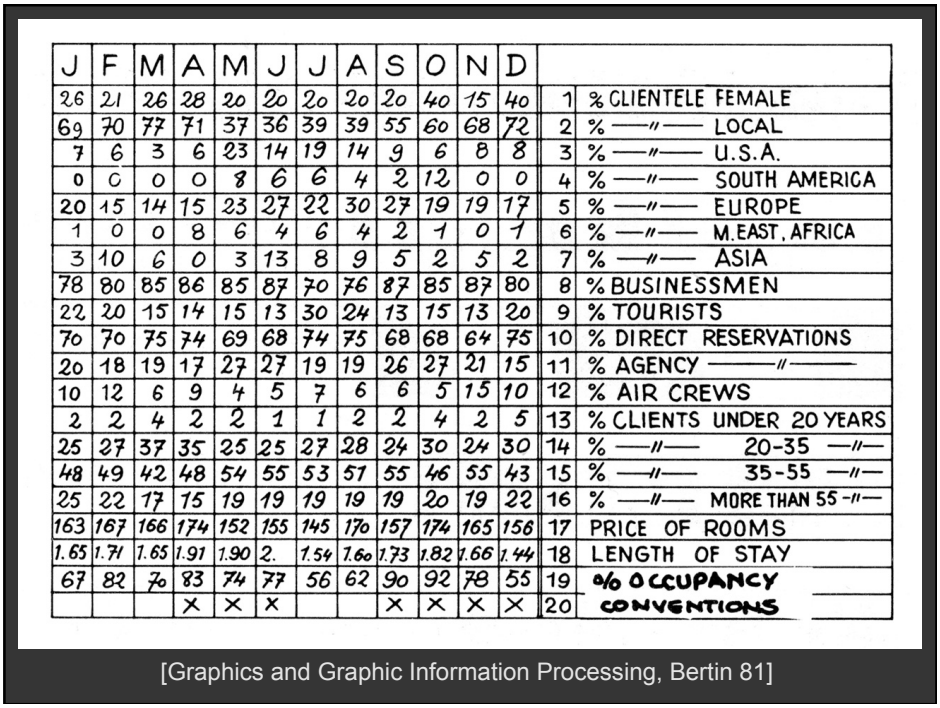
Gulf of execution



Topics

Early interactive systems
Brushing and linking
Dynamic queries
Generalized selections

Early Systems



J	F	M	A	M	J	J	A	S	O	N	D		
26	21	26	28	20	20	20	20	20	40	15	40	1	% CLIENTELE FEMALE
69	70	77	71	37	36	39	39	55	60	68	72	2	% —〃— LOCAL
7	6	3	6	23	14	19	14	9	6	8	8	3	% —〃— U.S.A.
0	0	0	0	8	6	6	4	2	12	0	0	4	% —〃— SOUTH AMERICA
20	15	14	15	23	27	22	30	27	19	19	17	5	% —〃— EUROPE
1	0	0	8	6	4	6	4	2	1	0	1	6	% —〃— M.EAST, AFRICA
3	10	6	0	3	13	8	9	5	2	5	2	7	% —〃— ASIA
78	80	85	86	85	87	70	76	87	85	87	80	8	% BUSINESSMEN
22	20	15	14	15	13	30	24	13	15	13	20	9	% TOURISTS
70	70	75	74	69	68	74	75	68	68	64	75	10	% DIRECT RESERVATIONS
20	18	19	17	27	27	19	19	26	27	21	15	11	% AGENCY ———〃———
10	12	6	9	4	5	7	6	6	5	15	10	12	% AIR CREWS
2	2	4	2	2	1	1	2	2	4	2	5	13	% CLIENTS UNDER 20 YEARS
25	27	37	35	25	25	27	28	24	30	24	30	14	% —〃— 20-35 —〃—
48	49	42	48	54	55	53	51	55	46	55	43	15	% —〃— 35-55 —〃—
25	22	17	15	19	19	19	19	19	20	19	22	16	% —〃— MORE THAN 55 —〃—
163	167	166	174	152	155	145	170	157	174	165	156	17	PRICE OF ROOMS
1.65	1.71	1.65	1.91	1.90	2.	1.54	1.60	1.73	1.82	1.66	1.44	18	LENGTH OF STAY
67	82	70	83	74	77	56	62	90	92	78	55	19	% OCCUPANCY
			X	X	X			X	X	X	X	20	CONVENTIONS

[Graphics and Graphic Information Processing, Bertin 81]

Bertin Matrices

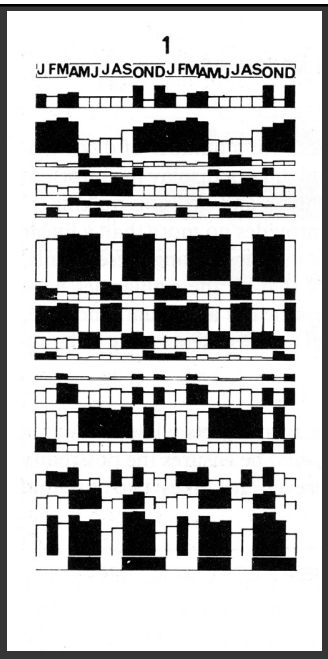
Research question

⬇

Table

⬇

1. **Encode table cells visually**
2. **Group similar rows and columns to reveal patterns**



[Graphics and Graphic Information Processing, Bertin 81]

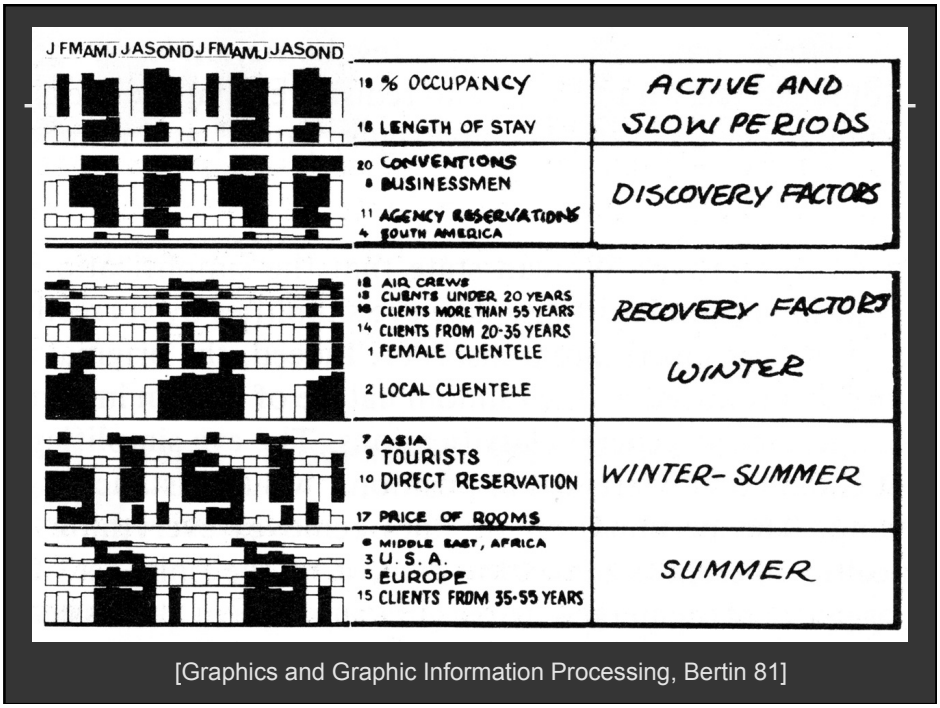
Group similar rows and columns

Choose a row with a particular visual aspect. Move to extremity of matrix.

Move similar rows close, opposite rows to bottom. (Creates two opposing groups and a middle group)

Repeat for columns

Iterate



[Graphics and Graphic Information Processing, Bertin 81]

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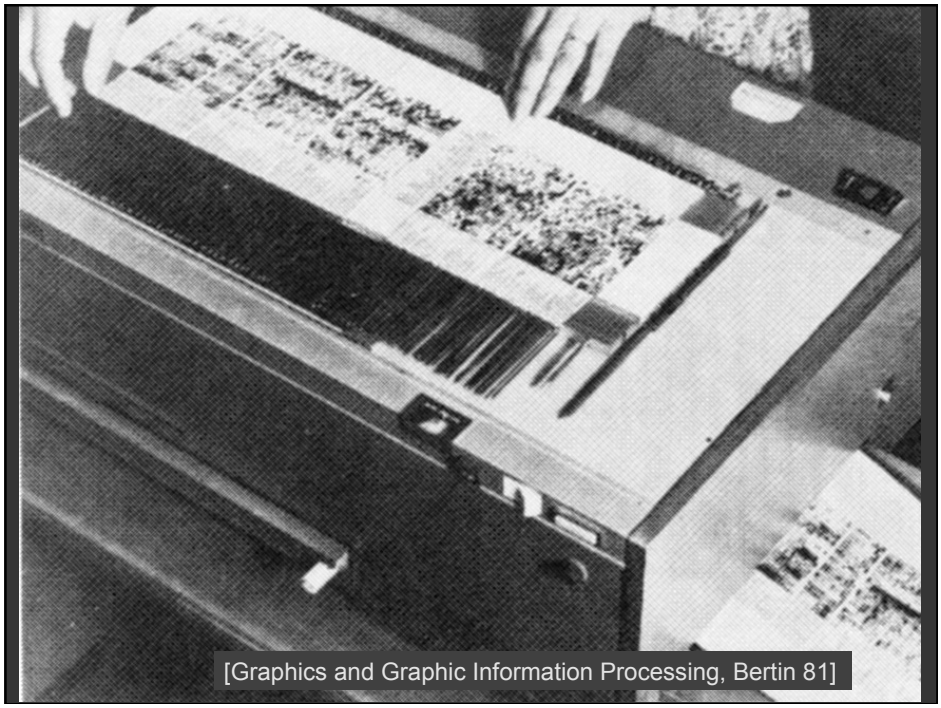
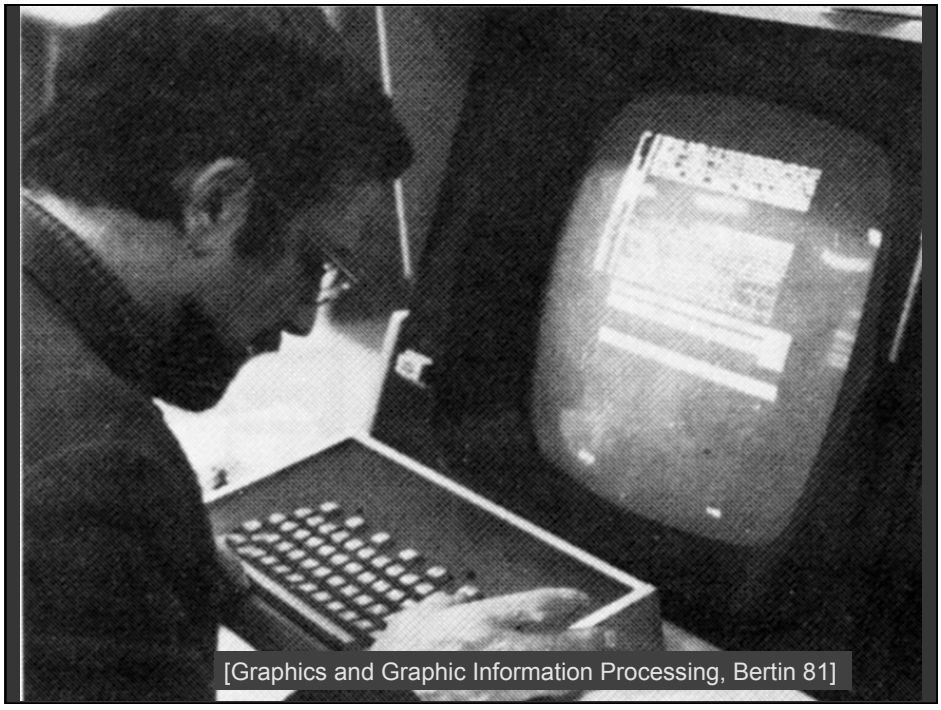


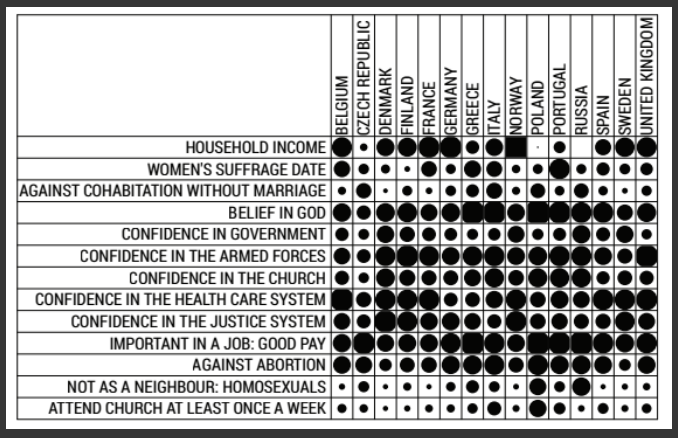
[Graphics and Graphic Information Processing, Bertin 81]



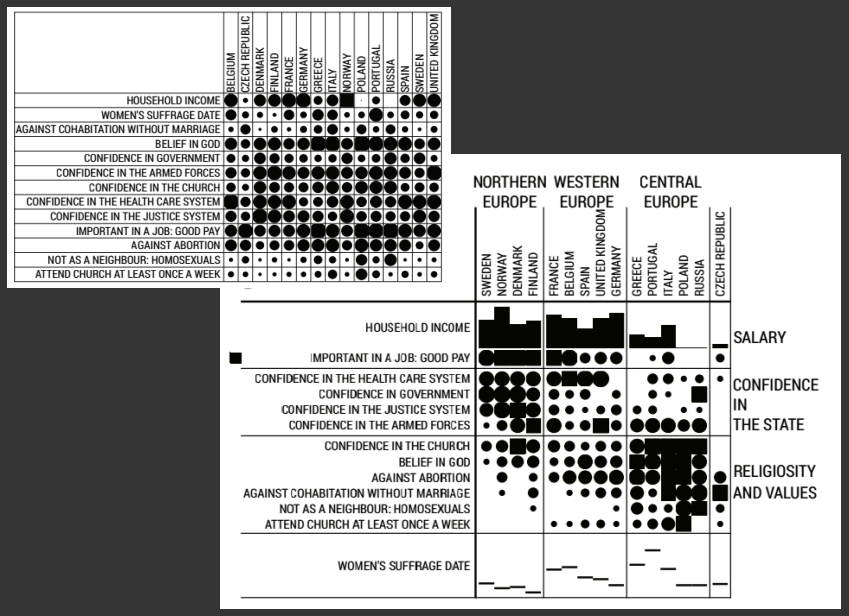
[Graphics and Graphic Information Processing, Bertin 81]

	Bel	Cze	Den	Fin	Fra	Ger	Gre	Ita	Nor	Pol	Por	Rus	Spa	Swe	Uni
Household in	268	169	246	257	283	287	204	242	314	153	193	152	228	262	269
Women's suf	194	192	191	190	194	191	195	194	191	191	197	191	193	192	192
Against coha	12	42	4	18	8	20	30	46	12	39	17	39	16	6	19
Belief in God	61	36	63	69	52	63	93	91	56	96	86	77	76	46	65
Confidence	32	21	55	42	34	29	22	28	51	23	30	60	35	54	19
Confidence	50	34	72	83	73	58	70	75	57	63	75	73	57	41	89
Confidence	36	20	63	47	41	40	52	67	44	65	67	67	31	39	36
Confidence	91	42	75	73	78	34	39	54	74	44	58	51	79	75	80
Confidence	50	35	87	73	56	58	50	36	78	44	48	41	42	69	51
Important in	60	85	54	58	58	73	94	76	56	93	88	93	77	62	75
Against abo	56	51	28	40	44	60	65	72	42	75	61	63	57	25	57
Not as a nei	7	22	5	12	5	16	30	21	6	52	21	61	5	7	10
Attend churc	15	13	5	7	11	12	19	35	9	54	25	8	21	9	17

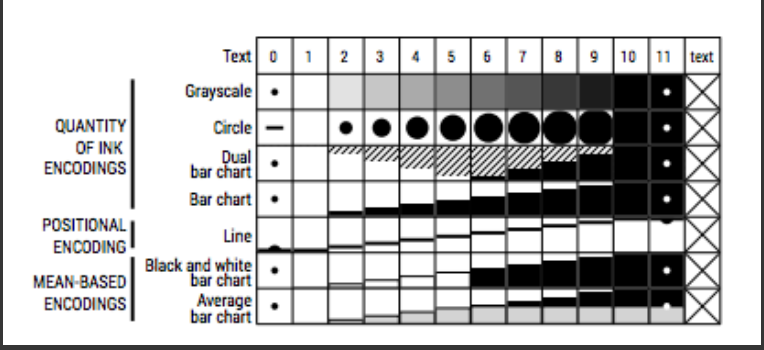
Bertifier [Perin 2014]



Bertifier [Perin 2014]



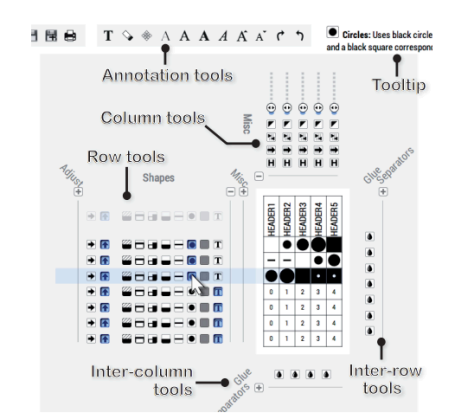
Visual encodings



Quantity of ink is proportional to the normalized data value

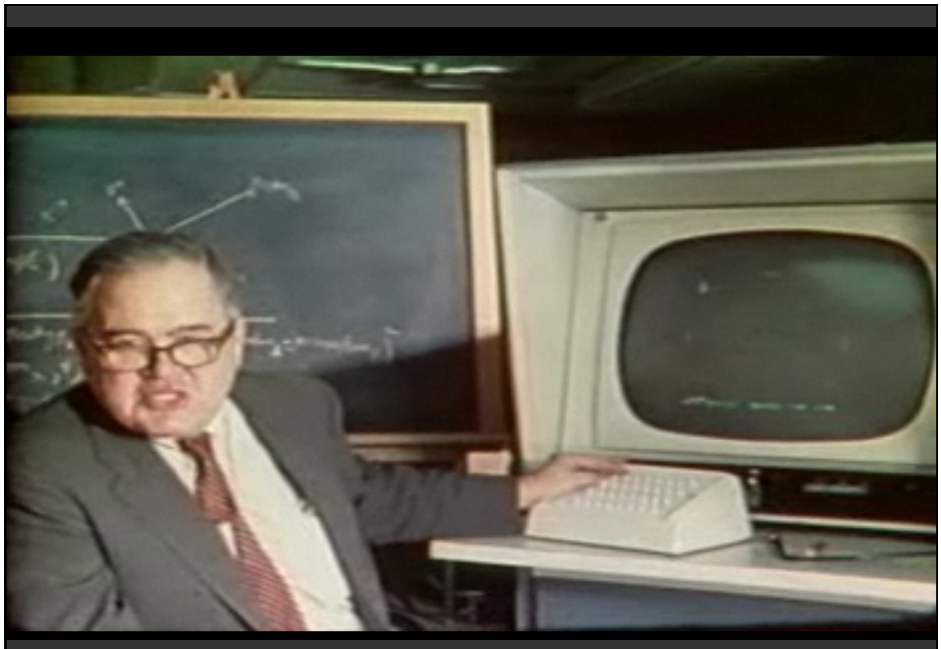
Reordering methods

Manual



Automatic

bertifier.com

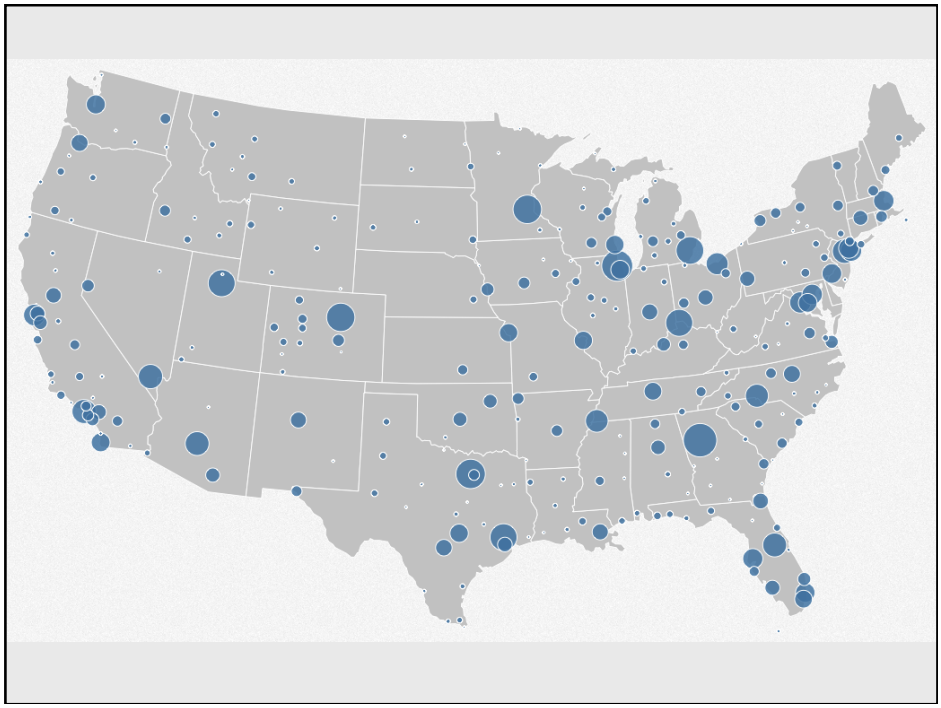


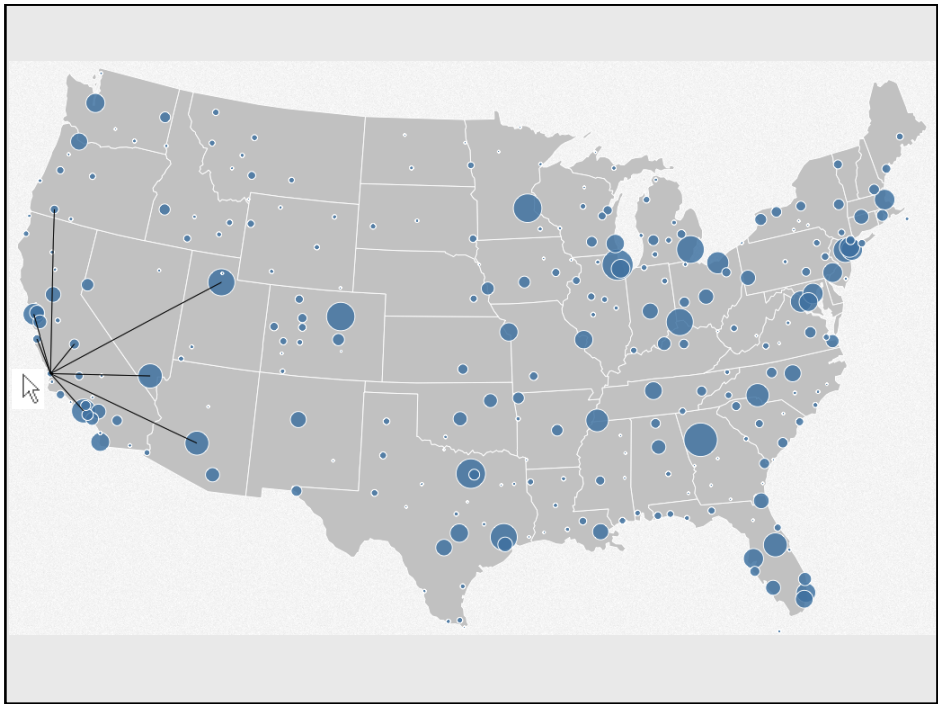
PRIM-9, Tukey, Fisherkeller, Friedman 1972

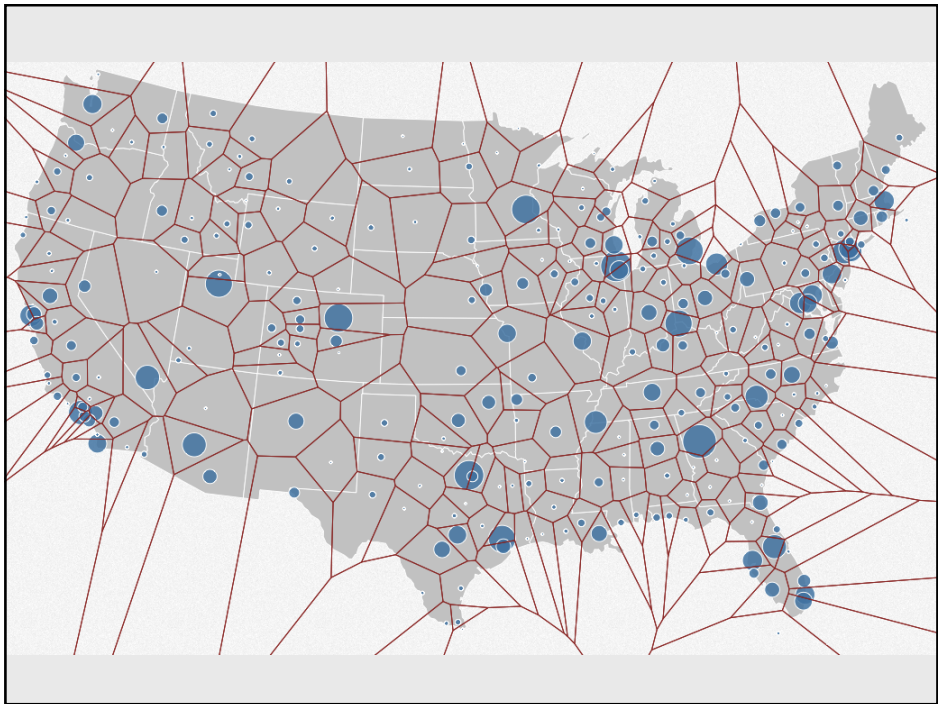
Pointing

Basic Pointing Methods

Point Selection
Mouse Hover / Click
Touch / Tap
Select Nearby Element (e.g., Bubble Cursor)







Basic Pointing Methods

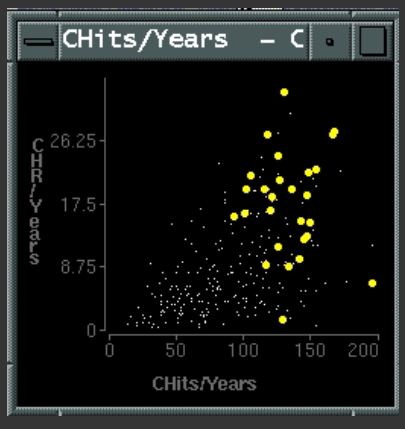
Point Selection
Mouse Hover / Click
Touch / Tap
Select Nearby Element (e.g., Bubble Cursor)

Region Selection
Rubber-band or Lasso
Area Cursors (“Brushes”)

Brushing and Linking

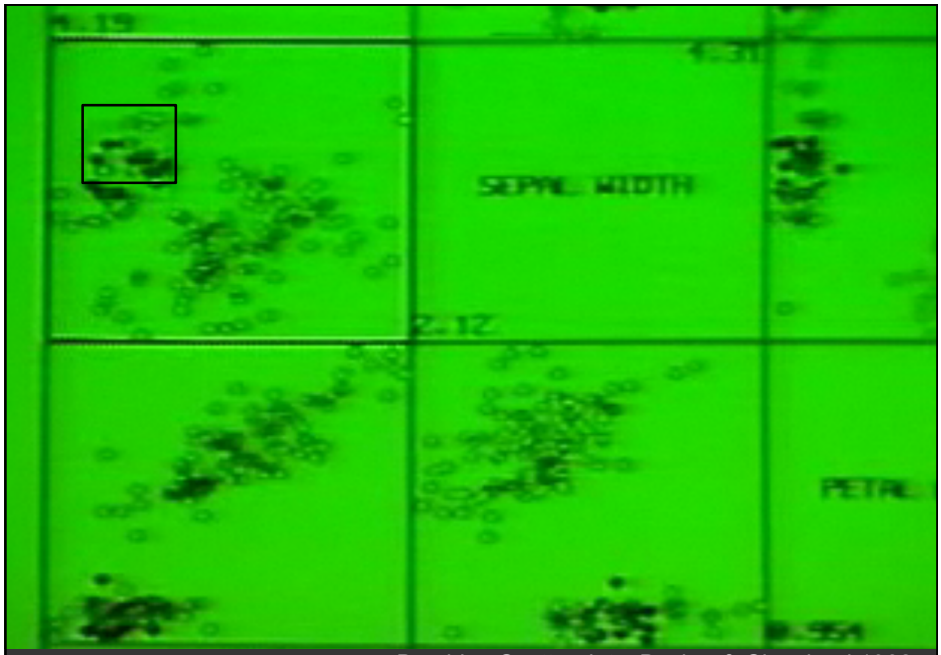
Highlighting

Focus user attention on a subset of the data within one graph [from Wills 95]



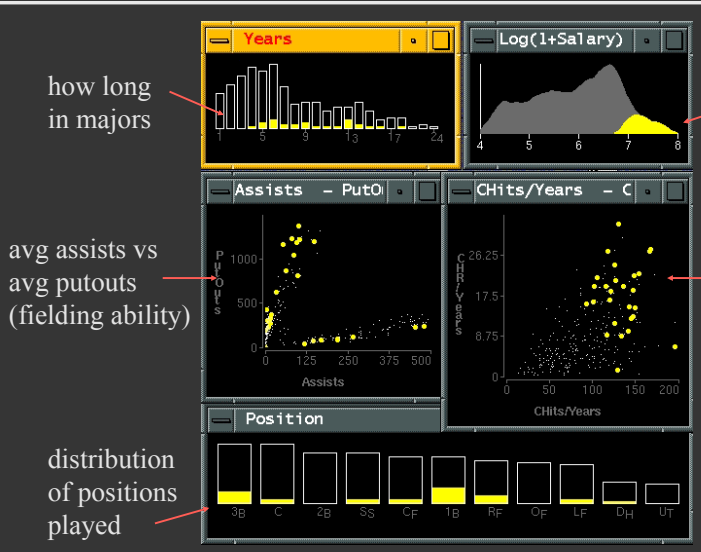
Brushing

- Interactively select subset of data
- See selected data in other views
- Two things (normally views) must be *linked* to allow for brushing

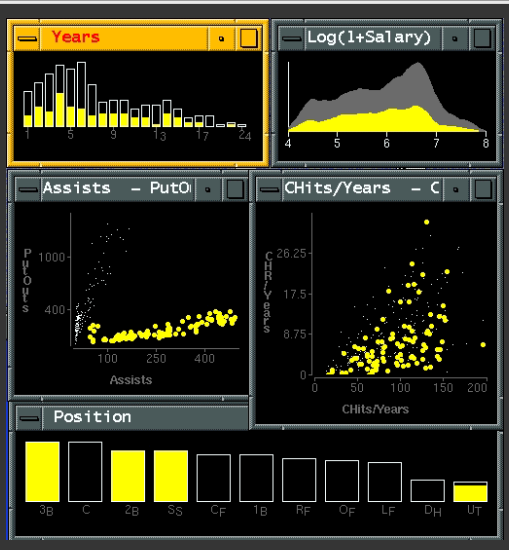


Brushing Scatterplots, Becker & Cleveland 1982

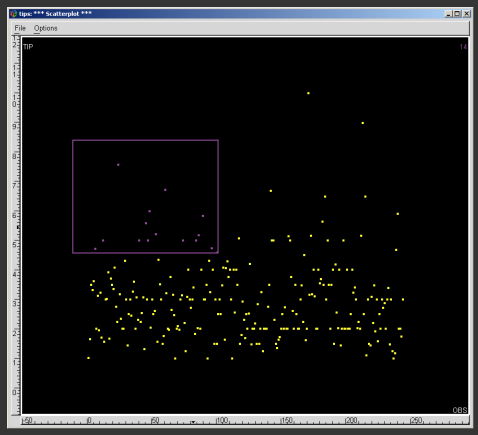
Baseball statistics [from Wills 95]

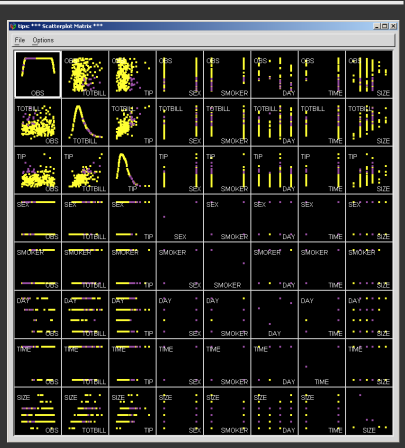


Linking assists to positions



GGobi: Brushing





http://www.ggobi.org/