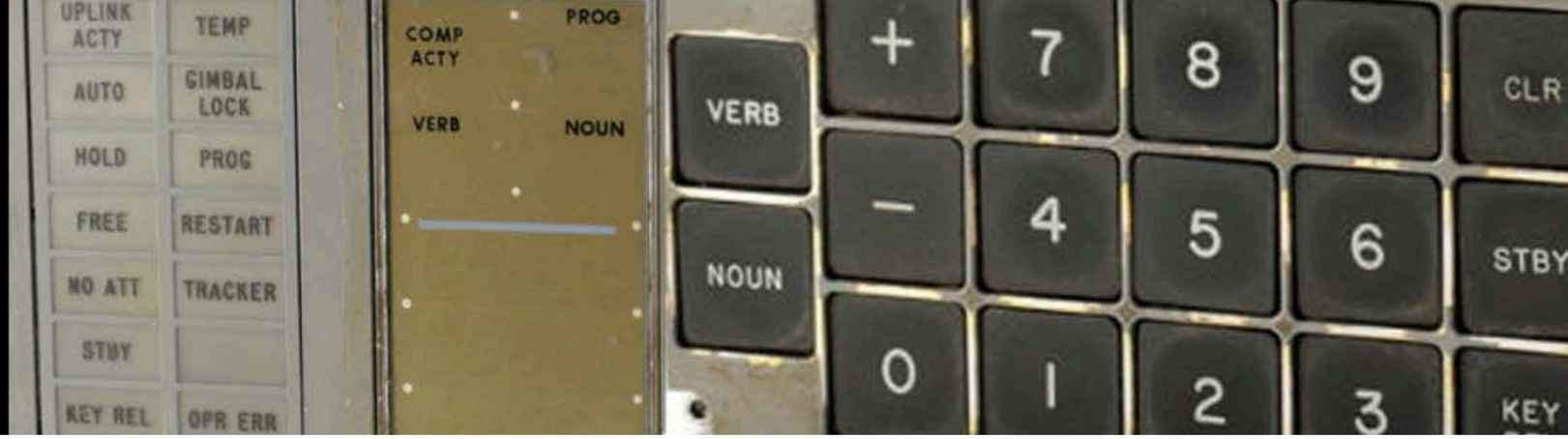
CS160

USER INTERFACE DESIGN

FALL 2020



INFORMATION VISUALIZATION

12 OCT 2020

ERIC PAULOS
www.paulos.net

UNIVERSITY OF CALIFORNIA Berkeley

ANNOUNCEMENTS

Plan for PROG 02

PROG 2-B (Due Friday 16 Oct) 5 DAYS!!

TODAY: Visual Information Design

Wed: Team Checking Office Hours (not a regular class) ▪ Breakout Rooms

DESIGN 05: Project Idea (due 19 Oct)

Be bold and creative in your idea

WHAT IS VISUALIZATION?

The depiction of information using spatial and graphical representations

Bringing information to life, visually

WHAT IS VISUALIZATION?

Visualize: to form a mental image or vision of.

Visualize: to imagine or remember as if actually seeing.

American Heritage dictionary, Concise Oxford dictionary

WHAT IS VISUALIZATION?

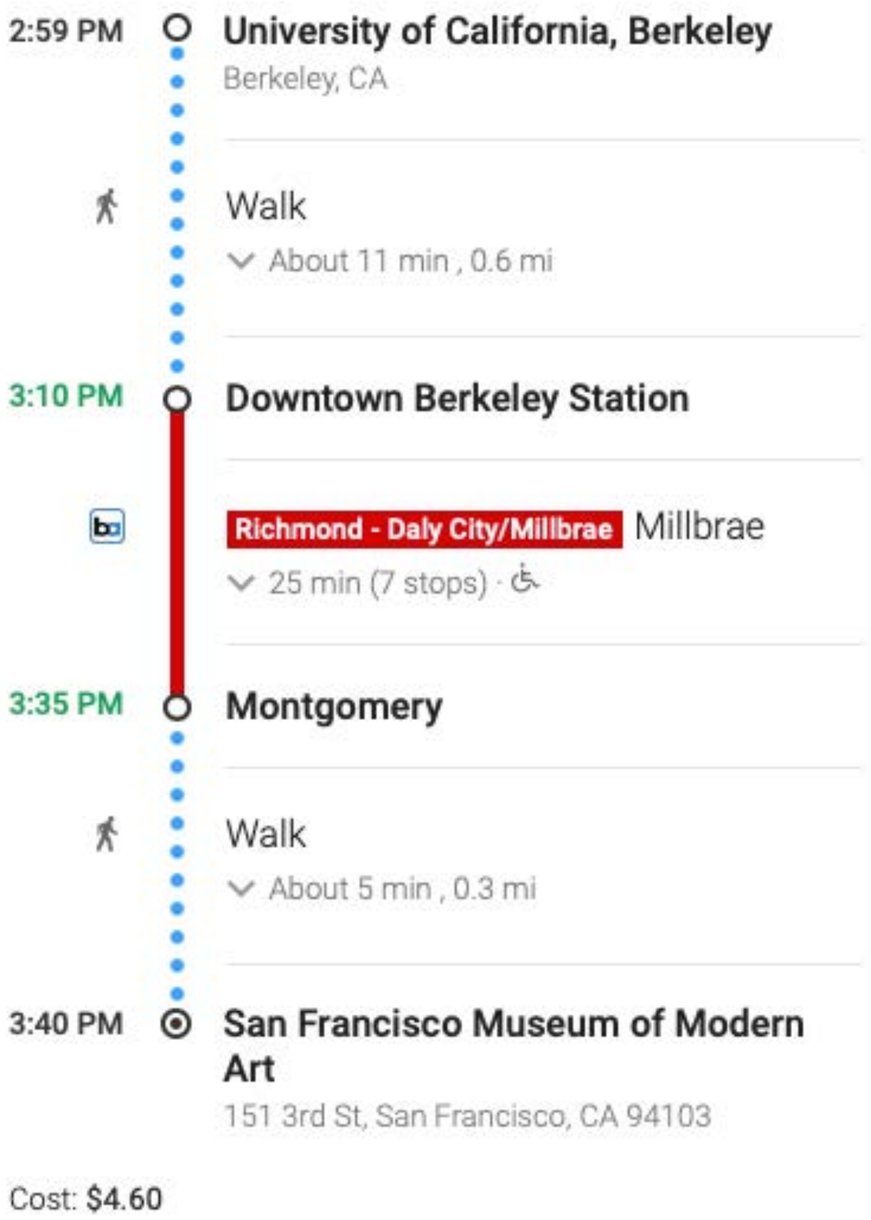
"Transformation of the symbolic into the geometric"
(McCormick et al., 1987)

"... finding the artificial memory that best
supports our natural means of perception."
(Bertin, 1983)

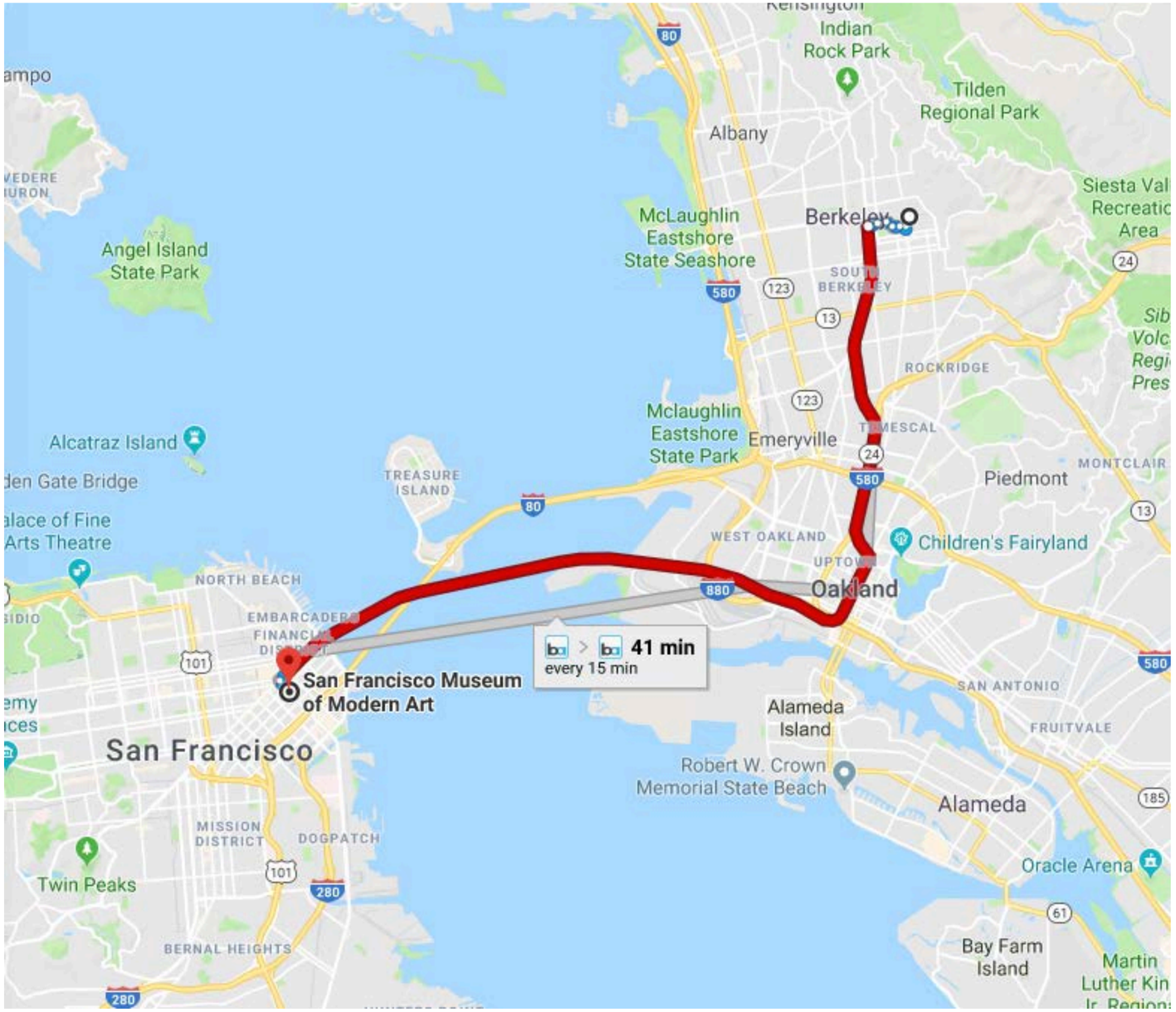
THE POWER OF VISUALIZATION

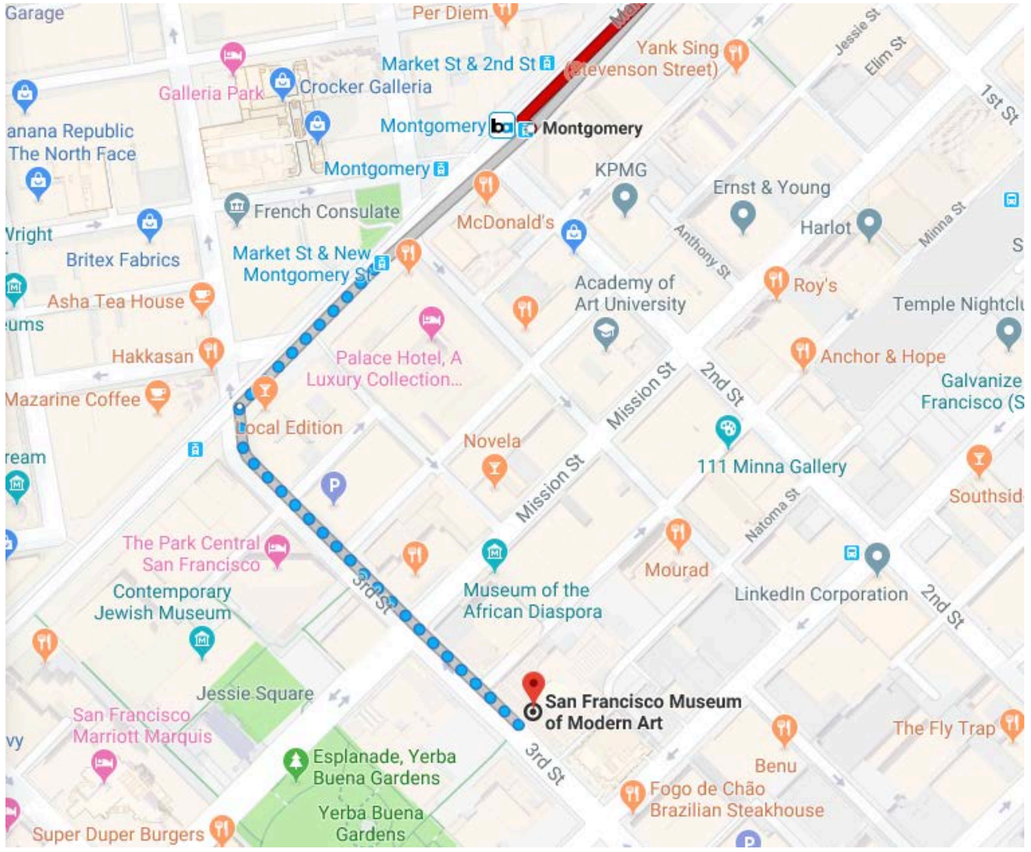
Walk
Head north on Sather Rd
Turn left toward Grade St
Slight right onto Grade St
Turn left toward Frank Schlessinger Way
Turn left onto Frank Schlessinger Way
Turn right onto Hilgard Way
Turn left onto Grinnell Pathway
Slight left onto Crescent Lawn
Continue onto Center St
Downtown Berkeley Station
Richmond - Daly City/MillbraeMillbrae
Montgomery Stop
Walk
Head southwest on Market St toward Annie St
Turn left onto 3rd St
Pass by Starbucks (on the left in 135 ft)
San Francisco Museum of Modern Art
151 3rd St, San Francisco, CA 94103

THE POWER OF VISUALIZATION

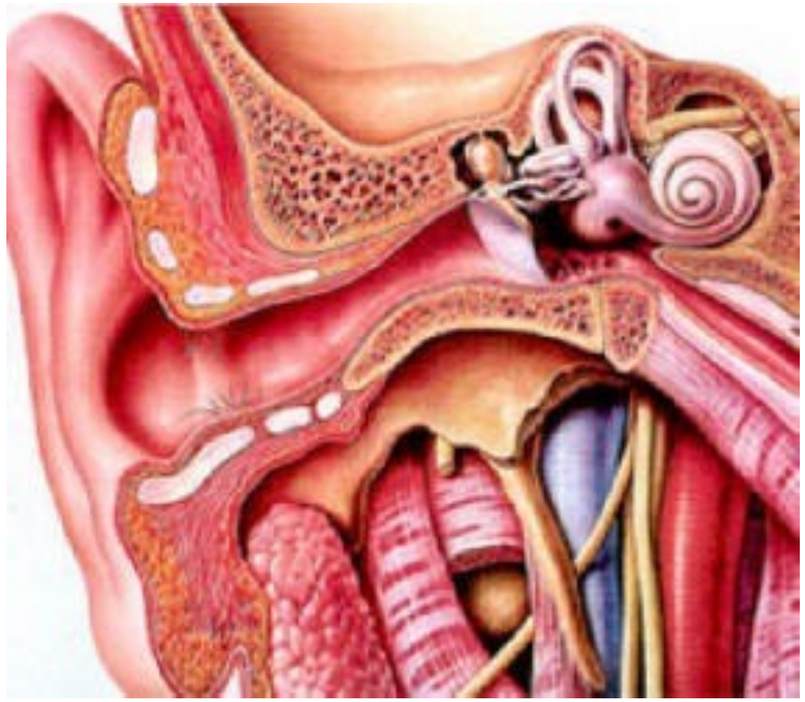


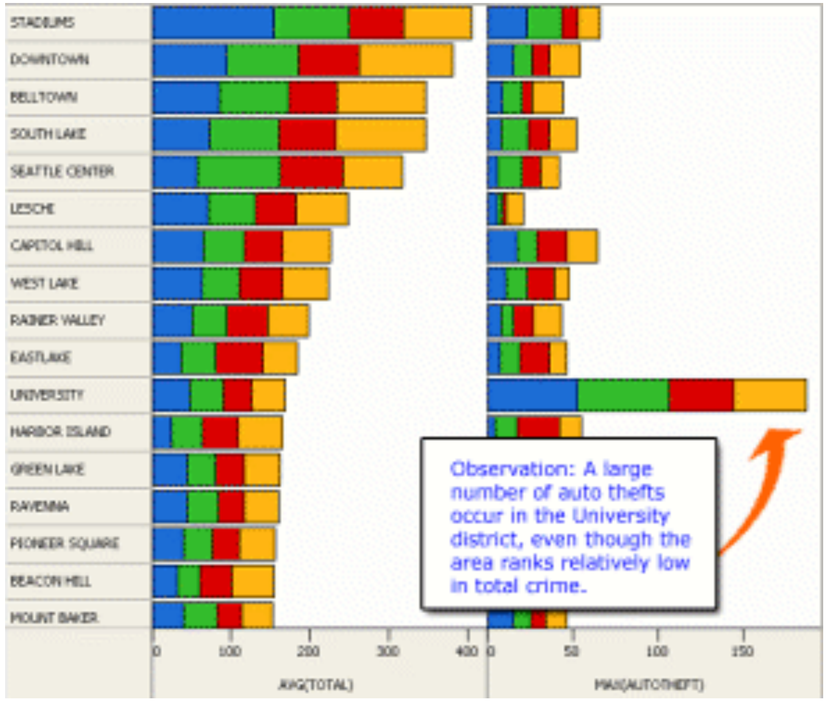
THE POWER OF VISUALIZATION

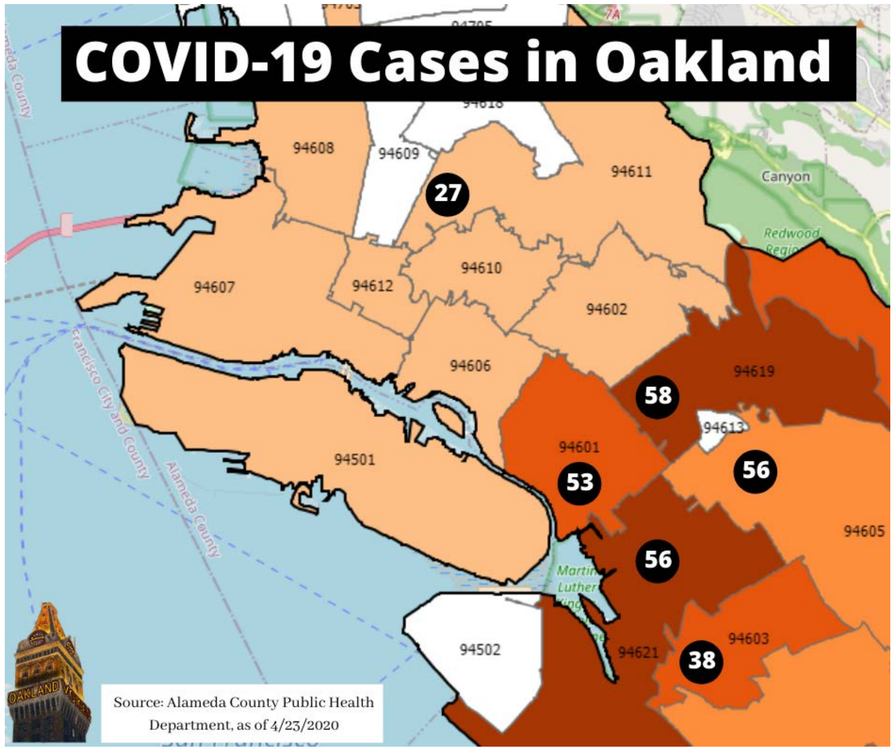




EXAMPLES

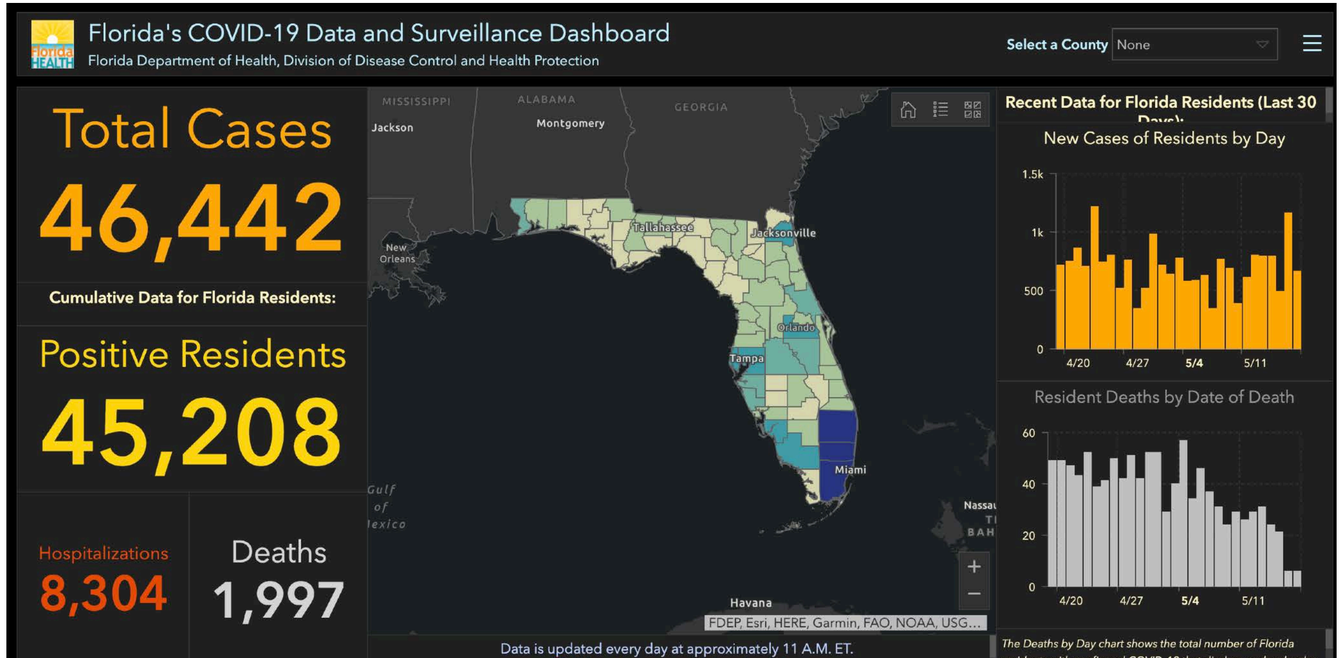



STADIUMS
DOWNTOWN
BELLTOWN
SOUTH LAKE
SEATTLE CENTER
LESCHI
CAPITOL HILL
WEST LAKE
RAINER VALLEY
EASTLAKE
UNIVERSITY
HARBOR ISLAND
GREEN LAKE
RAVENNA
PIONEER SQUARE
BEACON HILL
MOUNT BAKER
0
100
200
300
400
AVG(TOTAL)
0
50
100
150
MAX(AUTOTHEFT)
Observation: A large number of auto thefts occur in the University district, even though the area ranks relatively low in total crime.



Air Quality Index Levels of Health Concern	Numerical Value
Good	0 to 50
Moderate	51 to 100
Unhealthy for Sensitive Groups	101 to 150
Unhealthy	151 to 200
Very Unhealthy	201 to 300
Hazardous	301 to 500

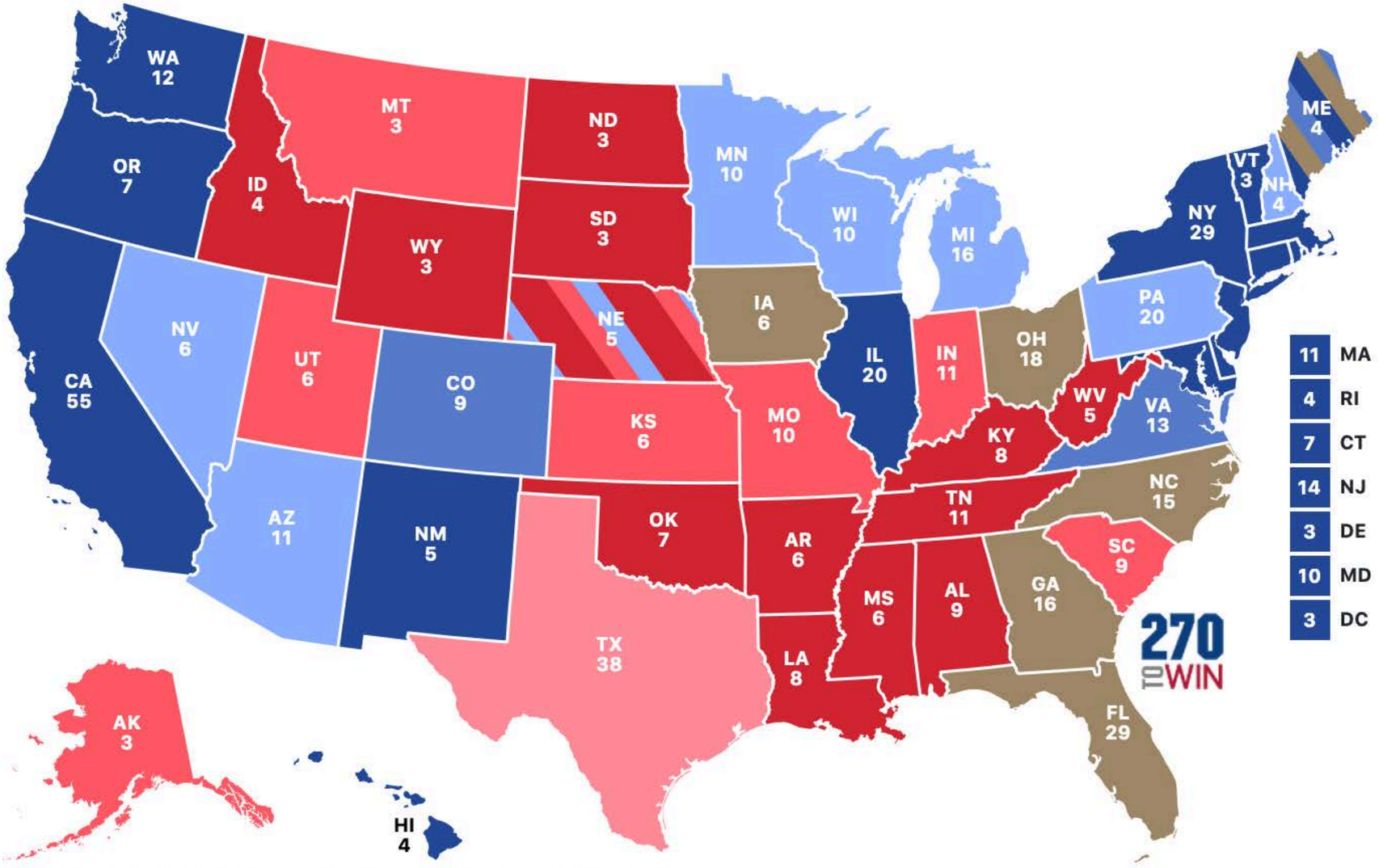
Note: Values above 500 are considered Beyond the AQI. Follow recommendations for the "Hazardous category." See additional information on reducing exposure to extremely high levels of particle pollution.



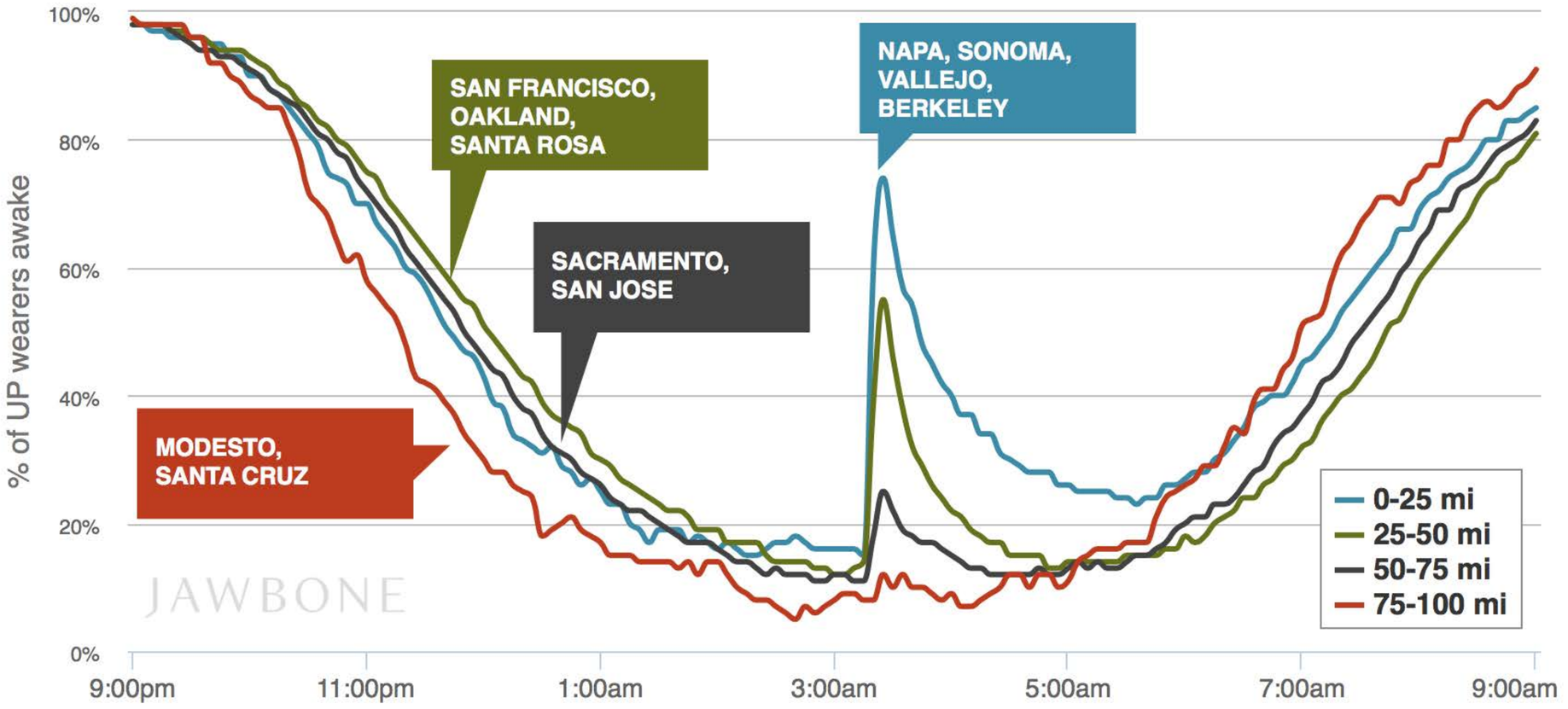
Biden 290 | 163 Trump

188 | 24 | 78 | 85 | 38 | 49 | 76

You are viewing: 2020 Consensus



Map Updated: Oct. 9, 2020 at 12:01 UTC (8:01 AM EDT)


100%
80%
60%
40%
20%
0%
% of UP wearers awake
9:00pm
11:00pm
1:00am
3:00am
5:00am
7:00am
9:00am
SAN FRANCISCO, OAKLAND, SANTA ROSA
SACRAMENTO, SAN JOSE
MODESTO, SANTA CRUZ
NAPA, SONOMA, VALLEJO, BERKELEY
0-25 mi
25-50 mi
50-75 mi
75-100 mi
JAWBONE

WHY DO WE CREATE VISUALIZATIONS?

THREE PRIMARY FUNCTIONS

Record information

- Photographs, blueprints, ...

Support reasoning about information (analyze)

- Process and calculate
- Reason about data
- Feedback and interaction

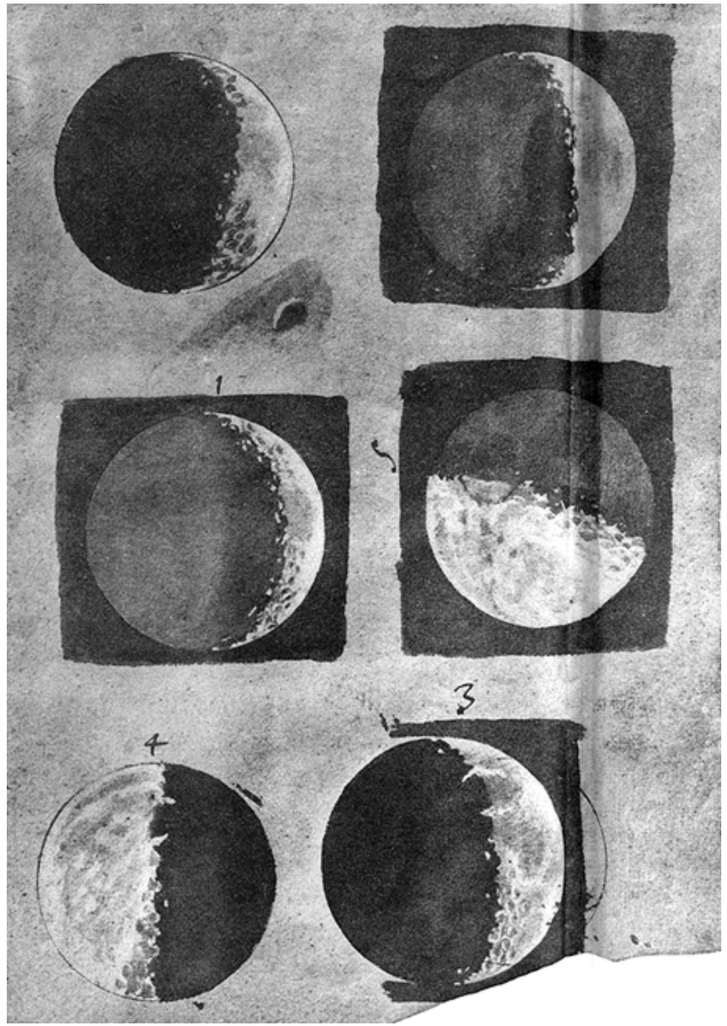
Convey information to others (present)

- Share and persuade
- Collaborate and revise
- Emphasize important aspects of data

RECORD INFORMATION

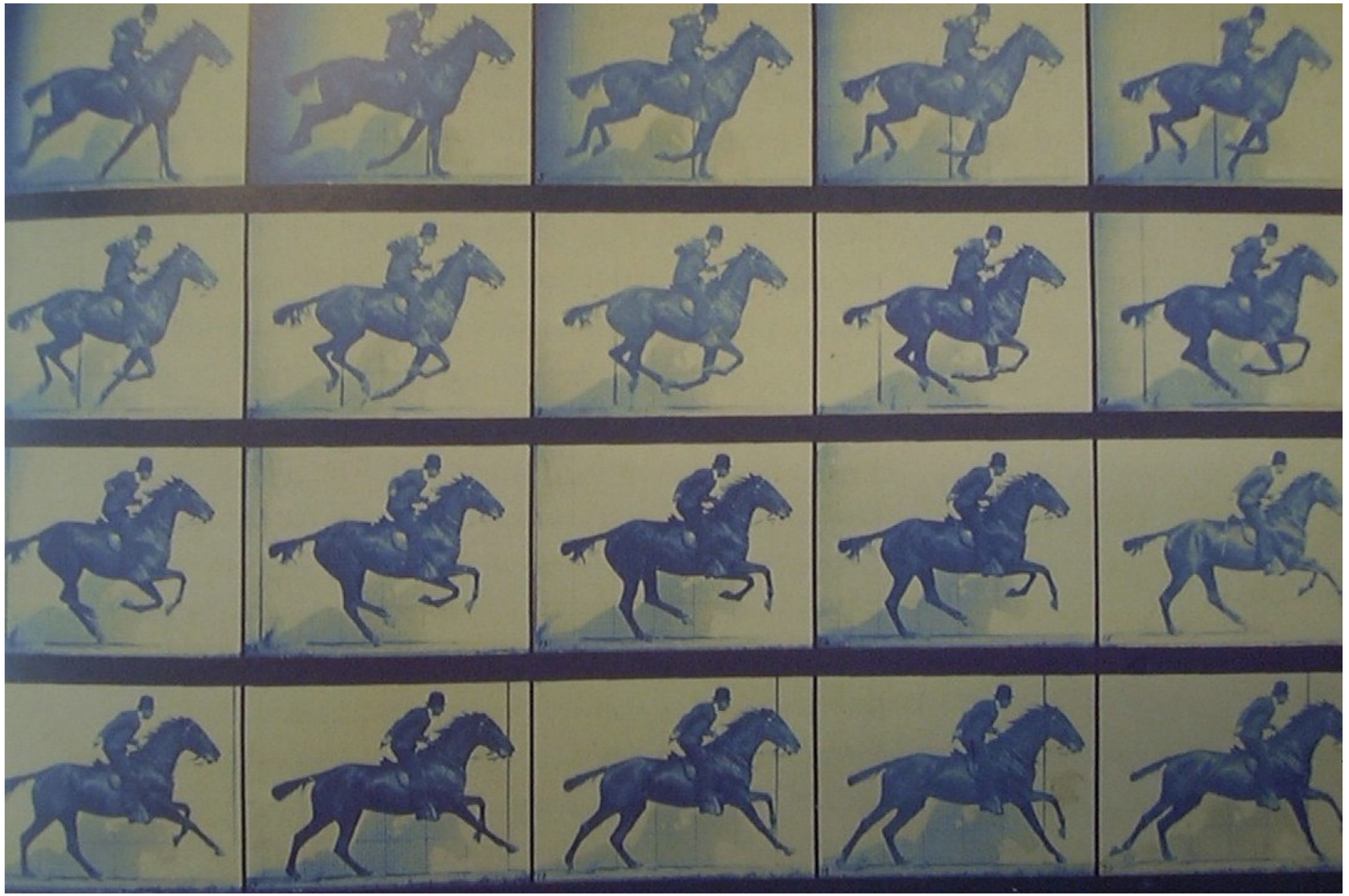
DRAWING: PHASES OF THE MOON

Galileo’s drawings of the phases of the moon from 1616



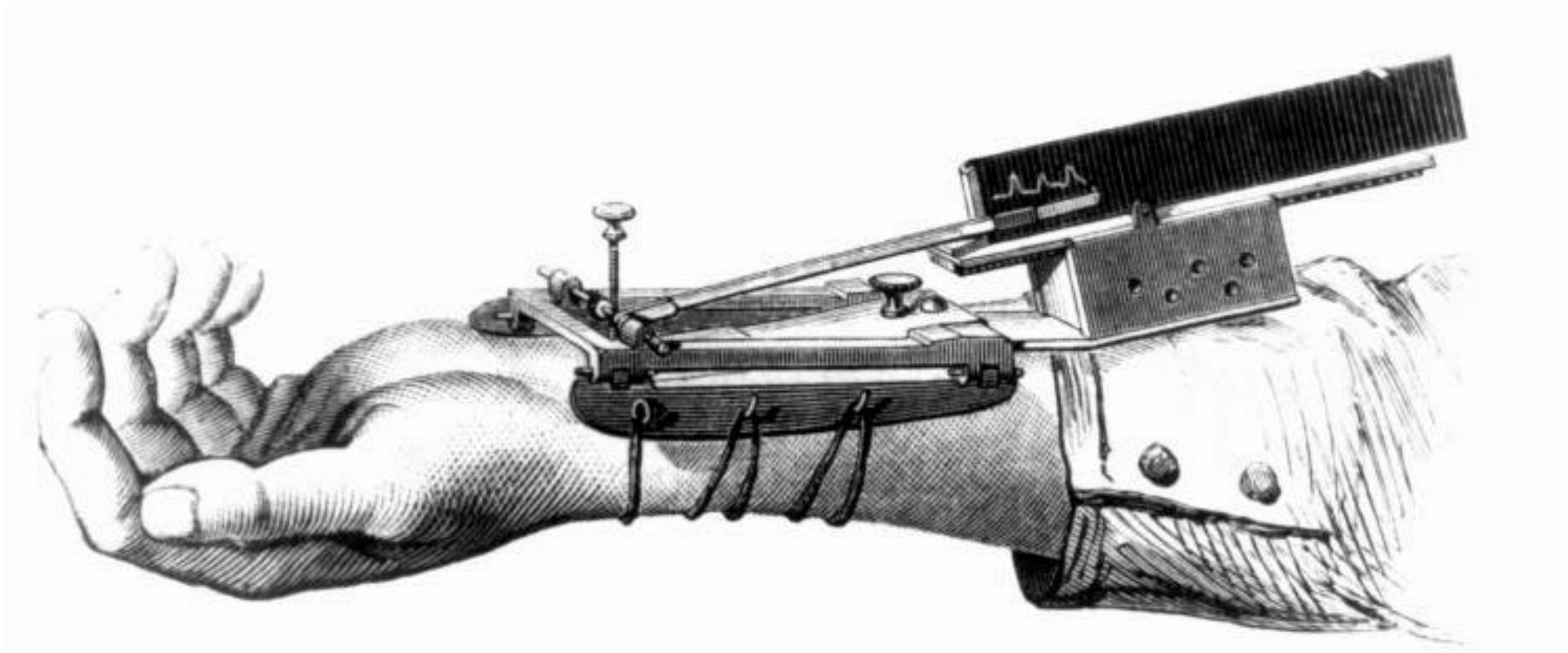
ANSWER QUESTION

Gallop, Bay Horse “Daisy” ▪ Muybridge 1884–86



OTHER RECORDING INSTRUMENTS

Marey’s sphygmograph



SUPPORT REASONING

INFORMATION VIZ PROBLEM SOLVING

Mystery: what is causing a cholera epidemic in London in 1854?

DATA IN CONTEXT: CHOLERA OUTBREAK

In 1864 John Snow plotted the position of each cholera case on a map

DATA IN CONTEXT: CHOLERA OUTBREAK

Used map to hypothesize that pump on Broad St. was the cause

MAKE A DECISION: CHALLENGER

2 of 13 pages of material faxed to NASA by Morton Thiokol

HISTORY OF O-RING DAMAGE ON SRM FIELD JOINTS

	SRM No.	Cross Sectional View: Erosion Depth (in.)	Cross Sectional View: Perimeter Affected (deg)	Cross Sectional View: Nominal Dia. (in.)	Top View: Length Of Max Erosion (in.)	Top View: Total Heat Affected Length (in.)	Clocking Location (deg)
AFT							
61A LH Center Field**	22A	None	None	0.280	None	None	36° --66°
61A LH ~~CENTER~~ FIELD**	22A	NONE	NONE	0.280	NONE	NONE	338°-18°
51C LH Forward Field**	15A	0.010	154.0	0.280	4.25	5.25	163
51C RH Center Field (prim)***	15B	0.038	130.0	0.280	12.50	58.75	354
51C RH Center Field (sec)***	15B	None	45.0	0.280	None	29.50	354
41D RH Forward Field	13B	0.028	110.0	0.280	3.00	None	275
41C LH Aft Field*	11A	None	None	0.280	None	None	--
41B LH Forward Field	10A	0.040	217.0	0.280	3.00	14.50	351
STS-2 RH Aft Field	2B	0.053	116.0	0.280	--	--	90

*Hot gas path detected in putty. Indication of heat on O-ring, but no damage.
**Soot behind primary O-ring.
***Soot behind primary O-ring, heat affected secondary O-ring.

Clocking location of leak check port - 0 deg.

OTHER SRM-15 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY AND NO SOOT NEAR OR BEYOND THE PRIMARY O-RING.

SRM-22 FORWARD FIELD JOINT HAD PUTTY PATH TO PRIMARY O-RING, BUT NO O-RING EROSION AND NO SOOT BLOWBY. OTHER SRM-22 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY.

Blow By History

SRM-15 worst Blow-By
- 2 case joints (80°), (110°) arc
- much worse visually than SRM-22

SRM 22 Blow-By
- 2 case joints (30-40°)

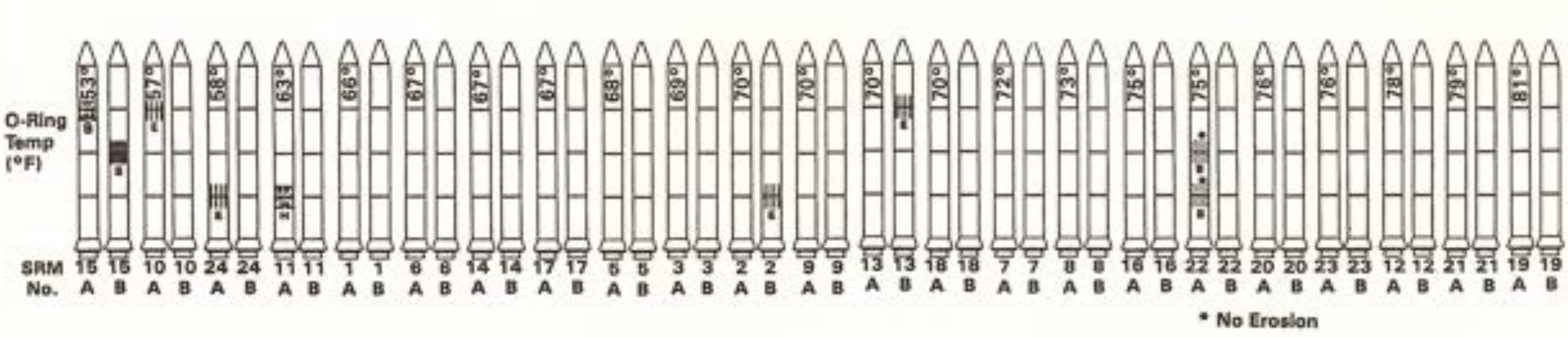
SRM-13A, 15, 16A, 18, 23A 24A
- nozzle Blow-By

HISTORY OF O-RING TEMPERATURES (DEGREES - F)

MOTOR	MBT	AMB	O-RING	WIND
DM-4	68	36	47	10 MPH
DM-2	76	45	52	10 MPH
QM-3	72.5	40	48	10 MPH
QM-4	76	48	51	10 MPH
SRM-15	52	64	53	10 MPH
SRM-22	77	78	75	10 MPH
SRM-25	55	26	29 27	10 MPH 25 MPH

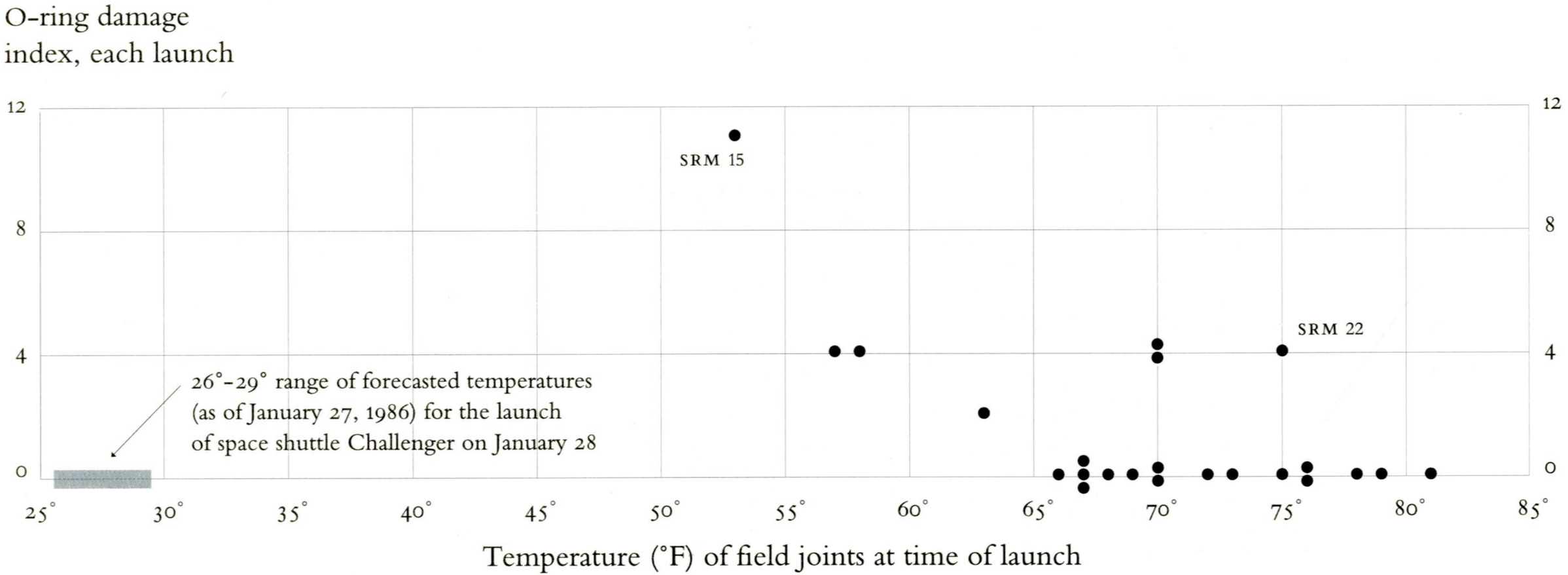
MAKE A DECISION: CHALLENGER

Visualizations by booster rocket manufacturer of damage to O-rings



MAKE A DECISION: CHALLENGER

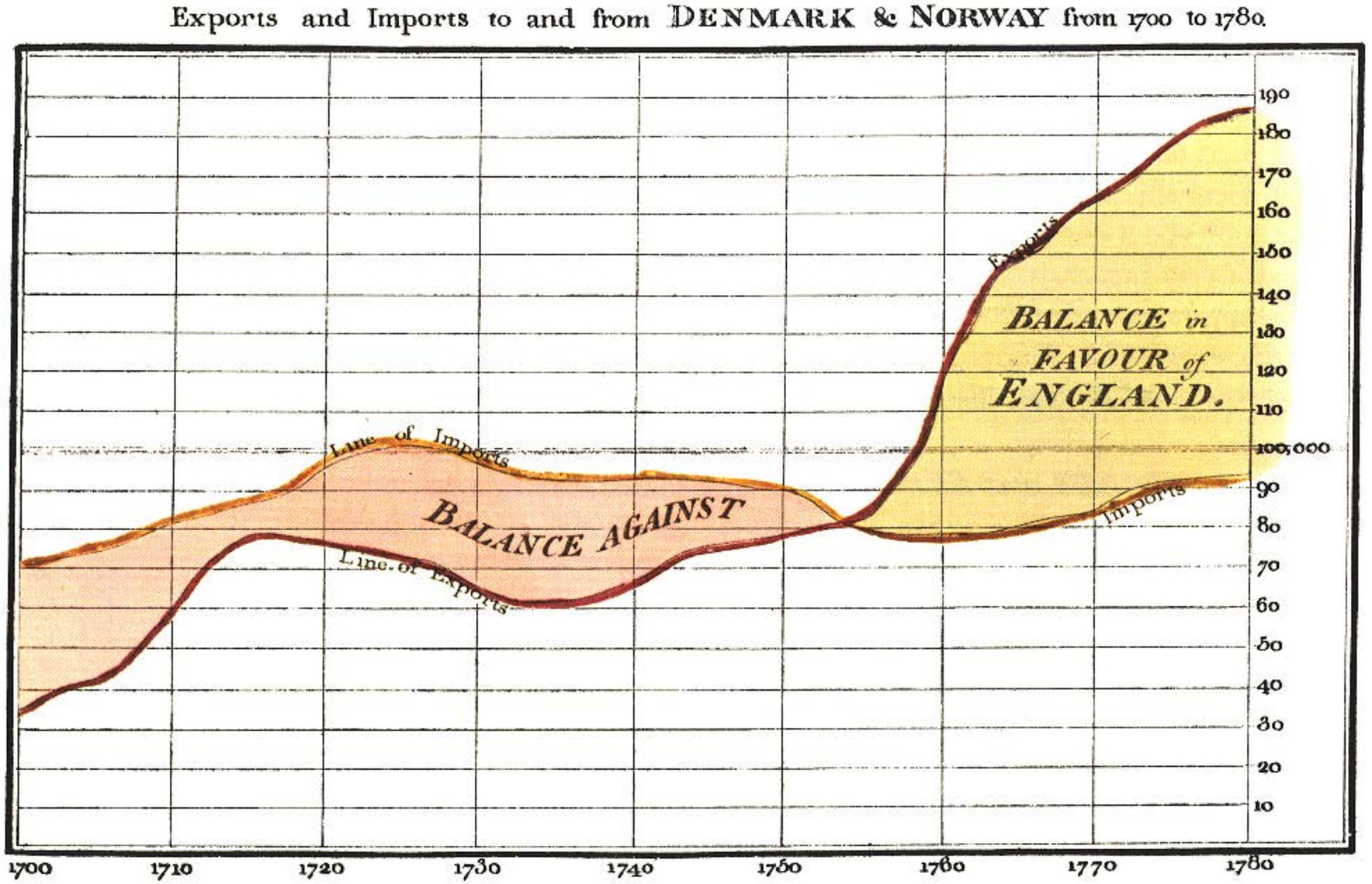
Visualizations showing how low temperatures damage O-rings



CONVEY INFORMATION TO OTHERS

PRESENT ARGUMENT: EXPORTS & IMPORTS

William Playfair 1786



TREE MAPS

The TreeMap (Johnson & Shneiderman ‘91)

Idea:

Show a hierarchy as a 2D layout

Fill up the space with rectangles representing objects

Nested rectangles indicated levels of hierarchy

Size on screen indicates relative size of underlying objects.

TREE MAP

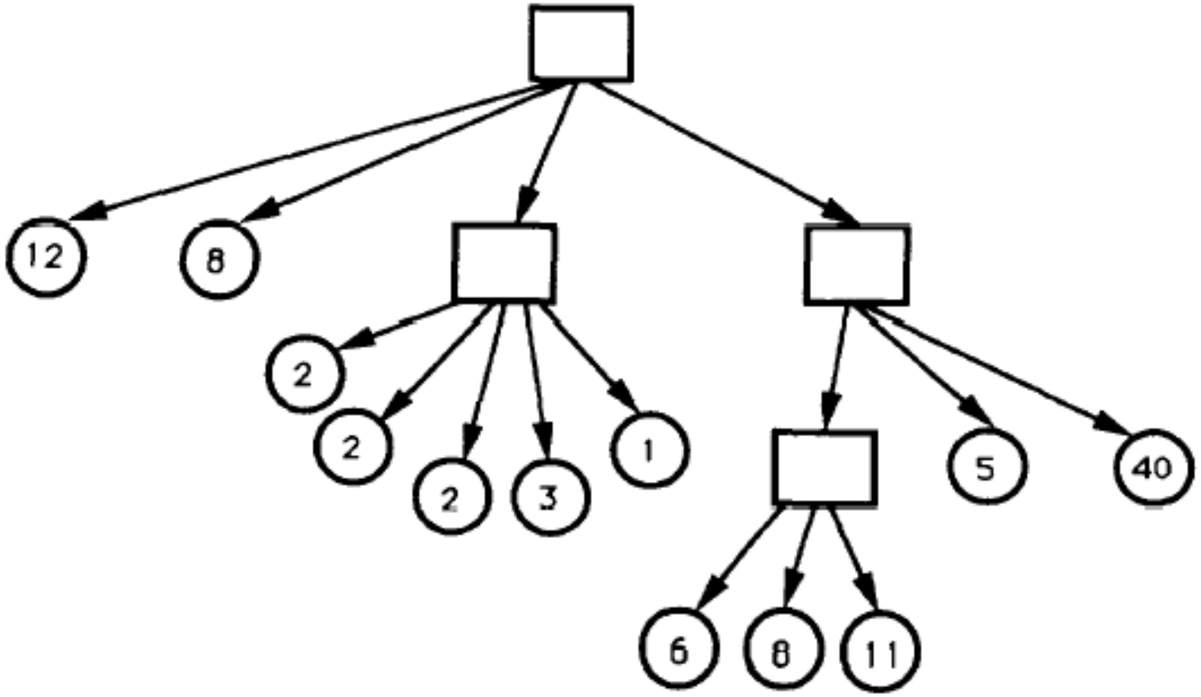


Fig. 1. Typical 3-level tree structure with numbers indicating size of each leaf node.

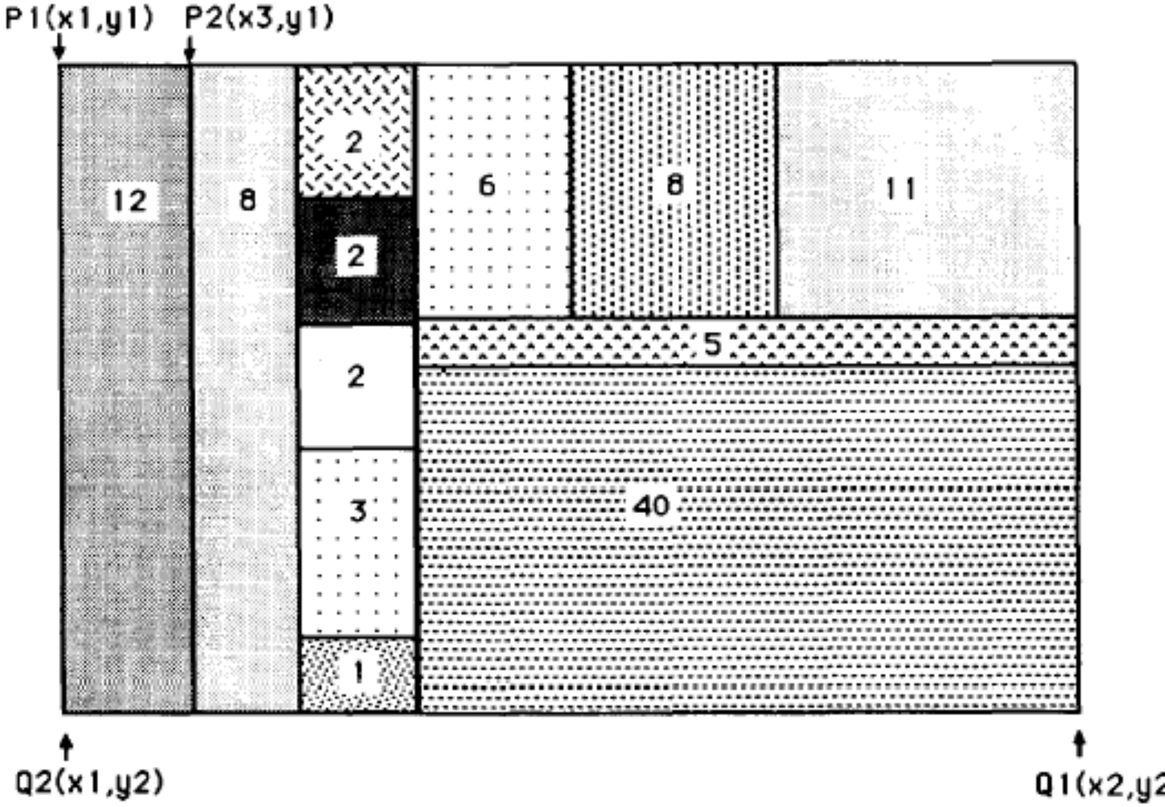


Fig. 2. Tree-map of Figure 1.

TREE MAP

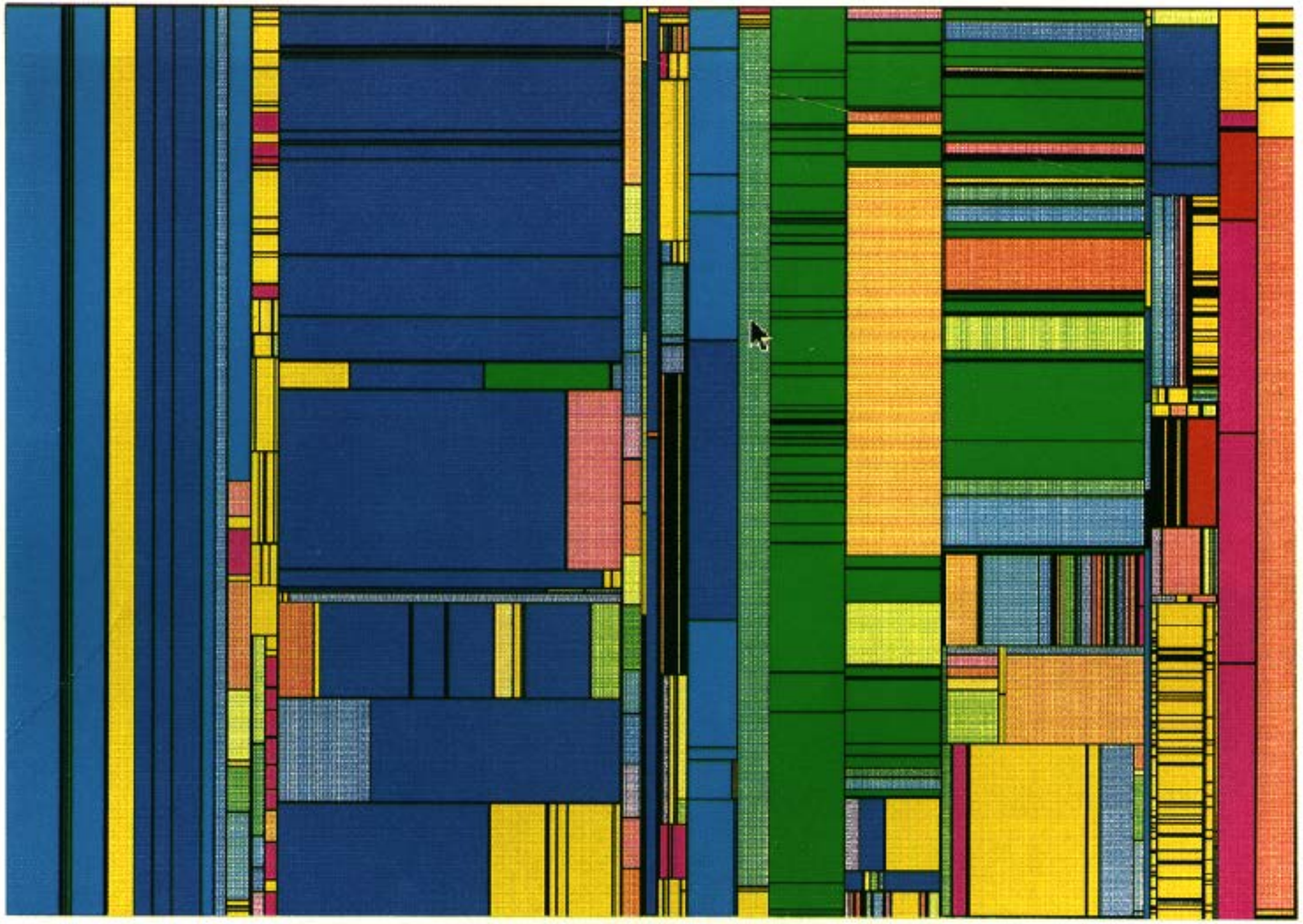


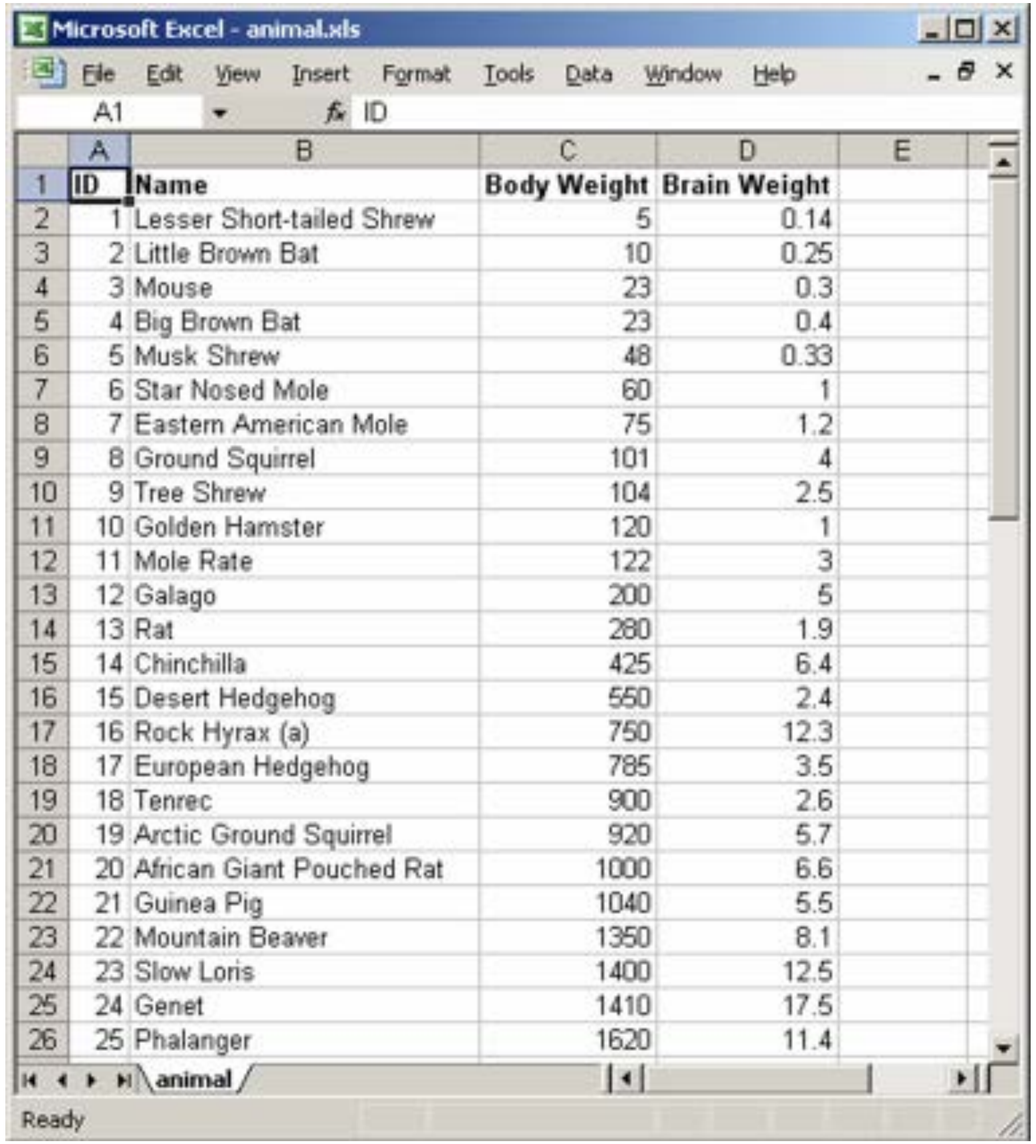
Fig. 4. 850 files at four levels with color coding by tile type. File name pops up when cursor rests on a file.

TREE MAP PROBLEMS

- Too disorderly
  - What does adjacency mean?
  - Aspect ratios uncontrolled leads to lots of skinny boxes that clutter
- Hard to understand
  - Must mentally convert nesting to hierarchy descent
- Color not used appropriately
  - In fact, is meaningless here
- Wrong application
  - Don’t need all this to just see the largest files in the OS

TREE MAP SUCCESSFUL APPLICATIONS

TELL STORY: MOST POWERFUL BRAIN?



Microsoft Excel - animal.xls

File Edit View Insert Format Tools Data Window Help

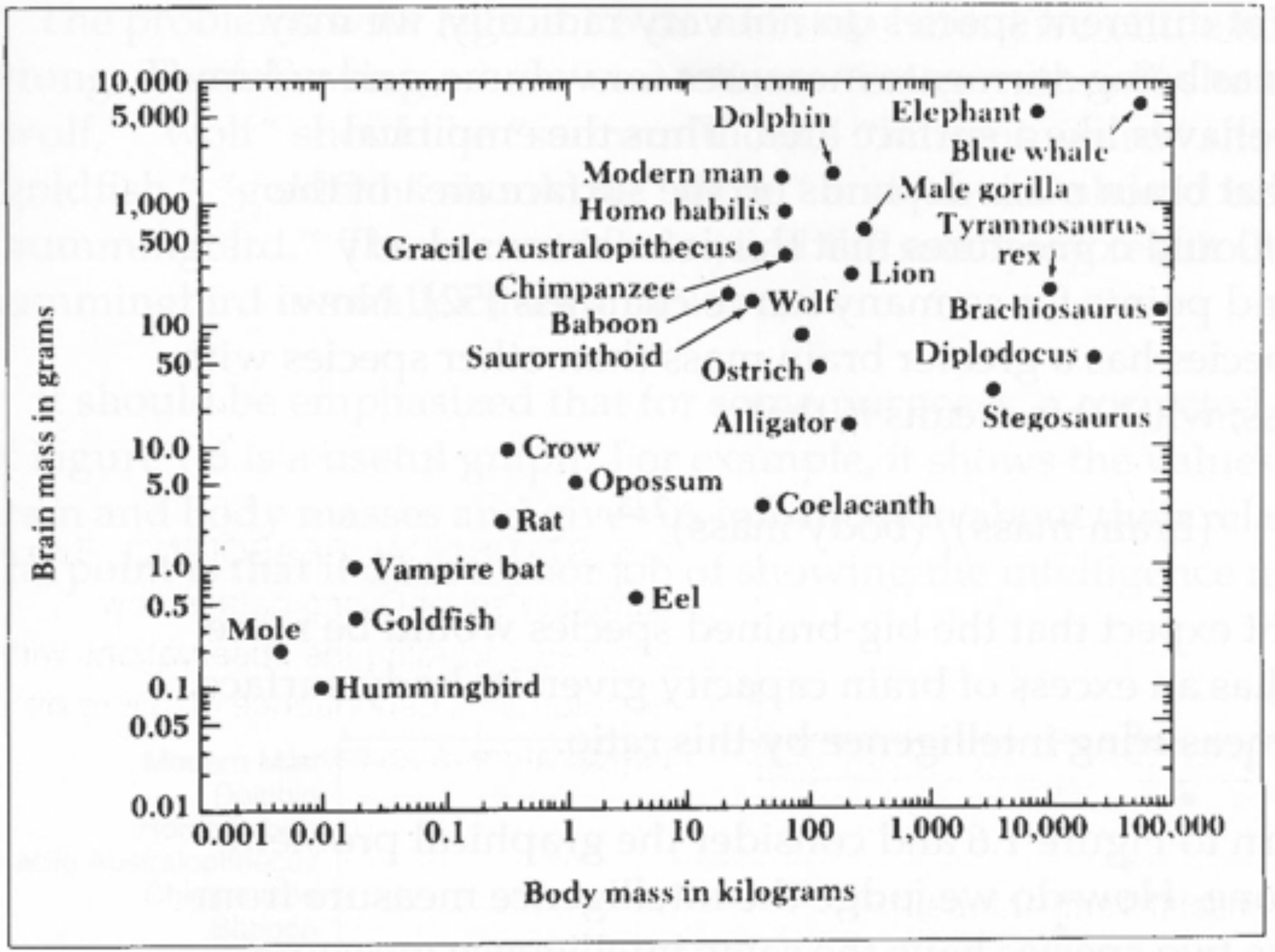
A1 ID

	A	B	C	D	E
1	ID	Name	Body Weight	Brain Weight	
2	1	Lesser Short-tailed Shrew	5	0.14	
3	2	Little Brown Bat	10	0.25	
4	3	Mouse	23	0.3	
5	4	Big Brown Bat	23	0.4	
6	5	Musk Shrew	48	0.33	
7	6	Star Nosed Mole	60	1	
8	7	Eastern American Mole	75	1.2	
9	8	Ground Squirrel	101	4	
10	9	Tree Shrew	104	2.5	
11	10	Golden Hamster	120	1	
12	11	Mole Rate	122	3	
13	12	Galago	200	5	
14	13	Rat	280	1.9	
15	14	Chinchilla	425	6.4	
16	15	Desert Hedgehog	550	2.4	
17	16	Rock Hyrax (a)	750	12.3	
18	17	European Hedgehog	785	3.5	
19	18	Tenrec	900	2.6	
20	19	Arctic Ground Squirrel	920	5.7	
21	20	African Giant Pouched Rat	1000	6.6	
22	21	Guinea Pig	1040	5.5	
23	22	Mountain Beaver	1350	8.1	
24	23	Slow Loris	1400	12.5	
25	24	Genet	1410	17.5	
26	25	Phalanger	1620	11.4	

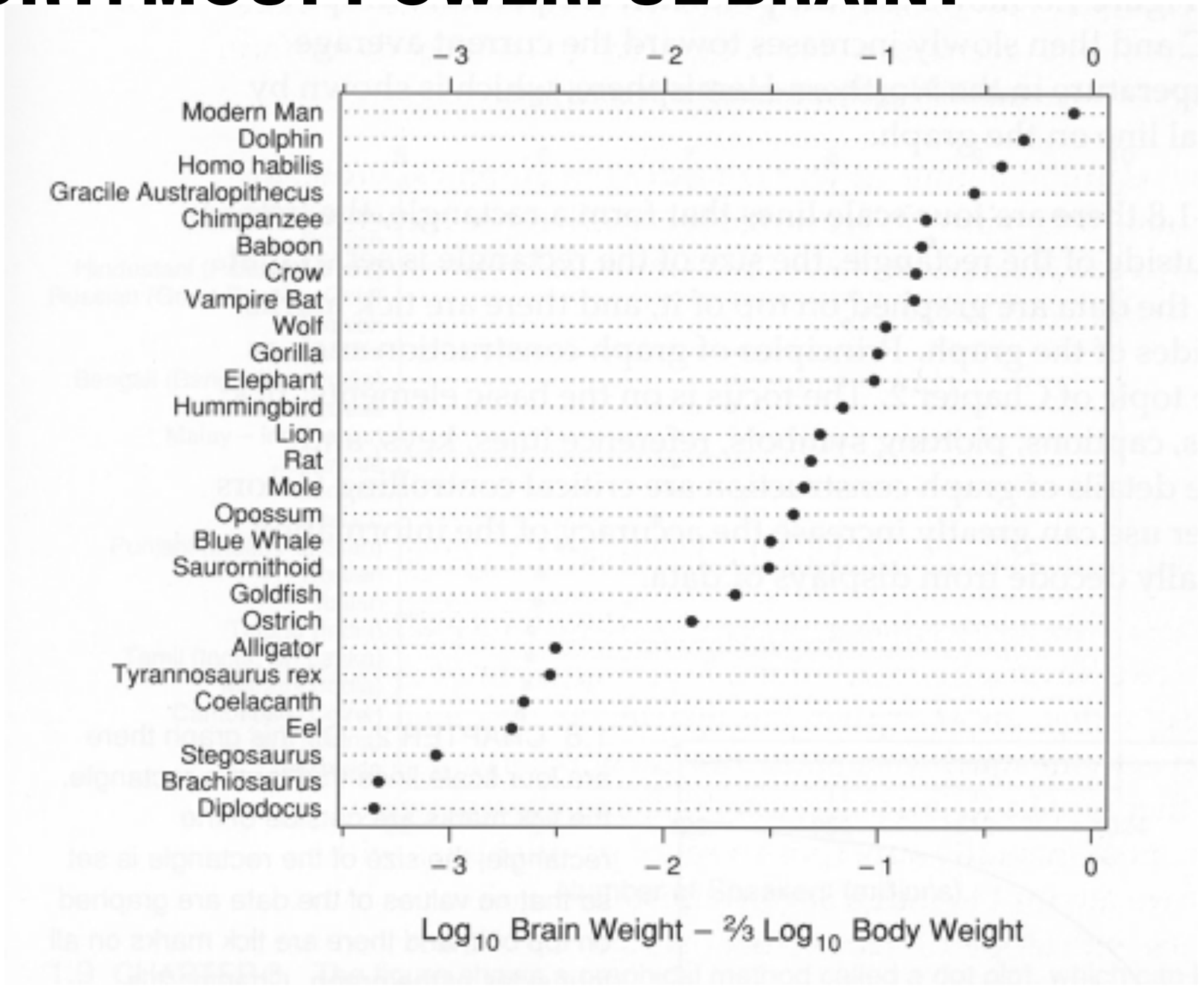
animal

Ready

TELL STORY: MOST POWERFUL BRAIN?



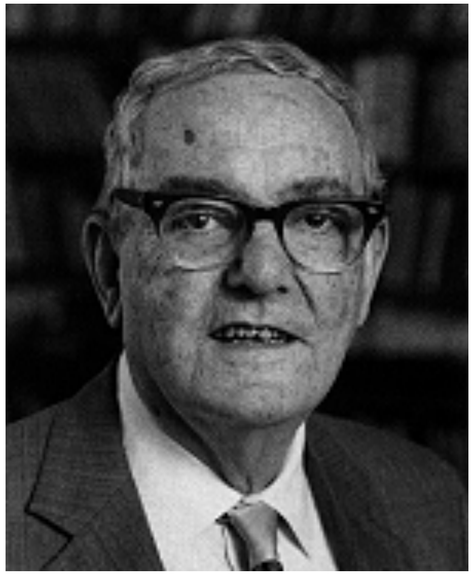
TELL STORY: MOST POWERFUL BRAIN?



ATTENTION

"What information consumes is rather obvious: it consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention, and a need to allocate that attention efficiently among the overabundance of information sources that might consume it."

— Herb Simon




UPLINK ACTY
TEMP
AUTO
GIMBAL LOCK
HOLD
PROG
FREE
RESTART
NO ATT
TRACKER
STBY
KEY REL
OPR ERR
COMP ACTY
PROG
VERB
NOUN
VERB
NOUN
+
7
8
9
CLR
−
4
5
6
STBY
0
1
2
3
KEY

DATA

DATA TYPES

Physical type (model)

Characterized by storage format

Characterized by machine operations

Example:

bool, short, int32, float, double, string, ...

Abstract type

Provide (conceptual) descriptions of the data

May be characterized by methods/attributes

May be organized into a hierarchy

Example:

nominal, ordinal, quantitative, ...,

plants, animals, metazoans, ...

NOMINAL, ORDINAL, AND QUANTITATIVE

N - Nominal (labels)

Fruits: Apples, oranges, ...

O - Ordered

Quality of meat: Grade A, AA, AAA

Q - Quantitative

Real numbers

Ordered, with measurable distances, or amounts

Dates: Jan, 19, 2006; Location: (LAT 33.98, LONG -118.45)

Physical measurement: Length, Mass, Temp, ...

FROM DATA MODEL TO DATA TYPE

Data model

32.5, 54.0, -17.3, …

floats

Conceptual model

Temperature

Data type

Burned vs. Not burned (N)

Hot, warm, cold (O)

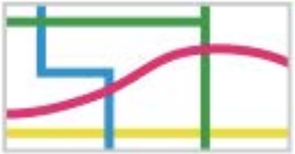
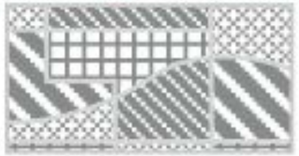
Continuous range of values (Q)


UPLINK ACTY
TEMP
AUTO
GIMBAL LOCK
HOLD
PROG
FREE
RESTART
NO ATT
TRACKER
STBY
KEY REL
OPR ERR
COMP ACTY
PROG
VERB
NOUN
VERB
NOUN
+
7
8
9
CLR
−
4
5
6
STBY
0
1
2
3
KEY

IMAGE

VISUAL VARIABLES

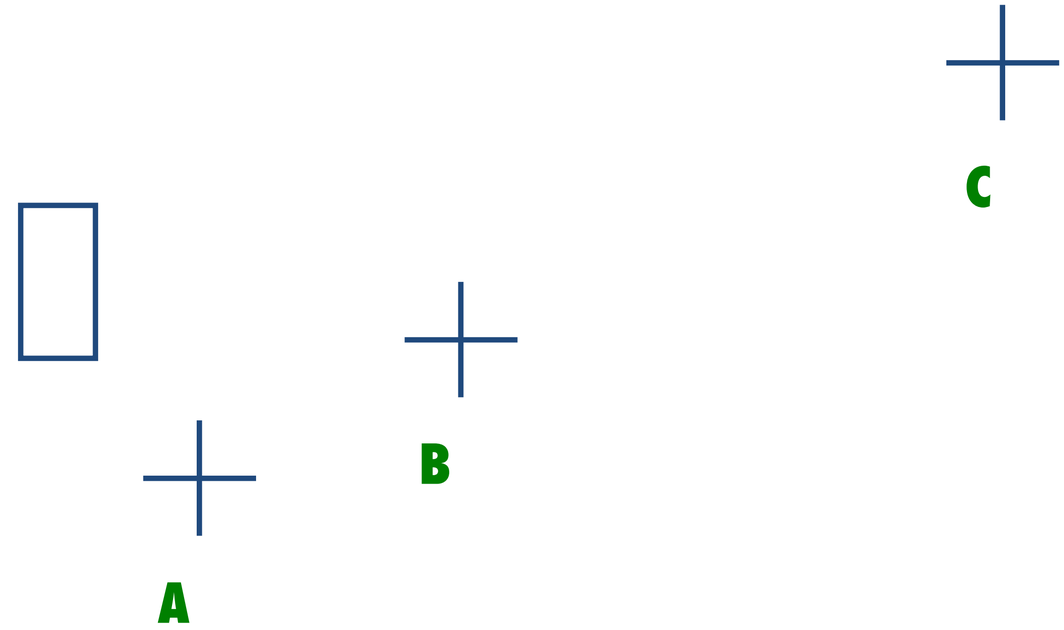
Jacques Bertin

	Points	Lines	Areas	Best to show
Shape		possible, but too weird to show	cartogram	qualitative differences
Size			cartogram	quantitative differences
Color Hue				qualitative differences
Color Value				quantitative differences
Color Intensity				qualitative differences
Texture				qualitative & quantitative differences

INFORMATION IN POSITION

1. A, B, C are distinguishable
2. B is between A and C.
3. BC is twice as long as AB.

4. ∴ Encode quantitative variables (Q)



INFORMATION IN COLOR AND VALUE

Value is perceived as ordered

∴ Encode ordinal variables (O)

∴ Encode continuous variables (Q) [not as well] – can't tell distance

Hue is normally perceived as unordered

∴ Encode nominal variables (N) using color

BERTINS' "LEVELS OF ORGANIZATION"

N Nominal

O Ordinal

Q Quantitative

Position	N	O	Q
Size	N	O	Q
Value	N	O	Q
Texture	N	O	
Color	N		
Orientation	N		
Shape	N		

ESTIMATING MAGNITUDE

DETECTING BRIGHTNESS

Which is brighter?

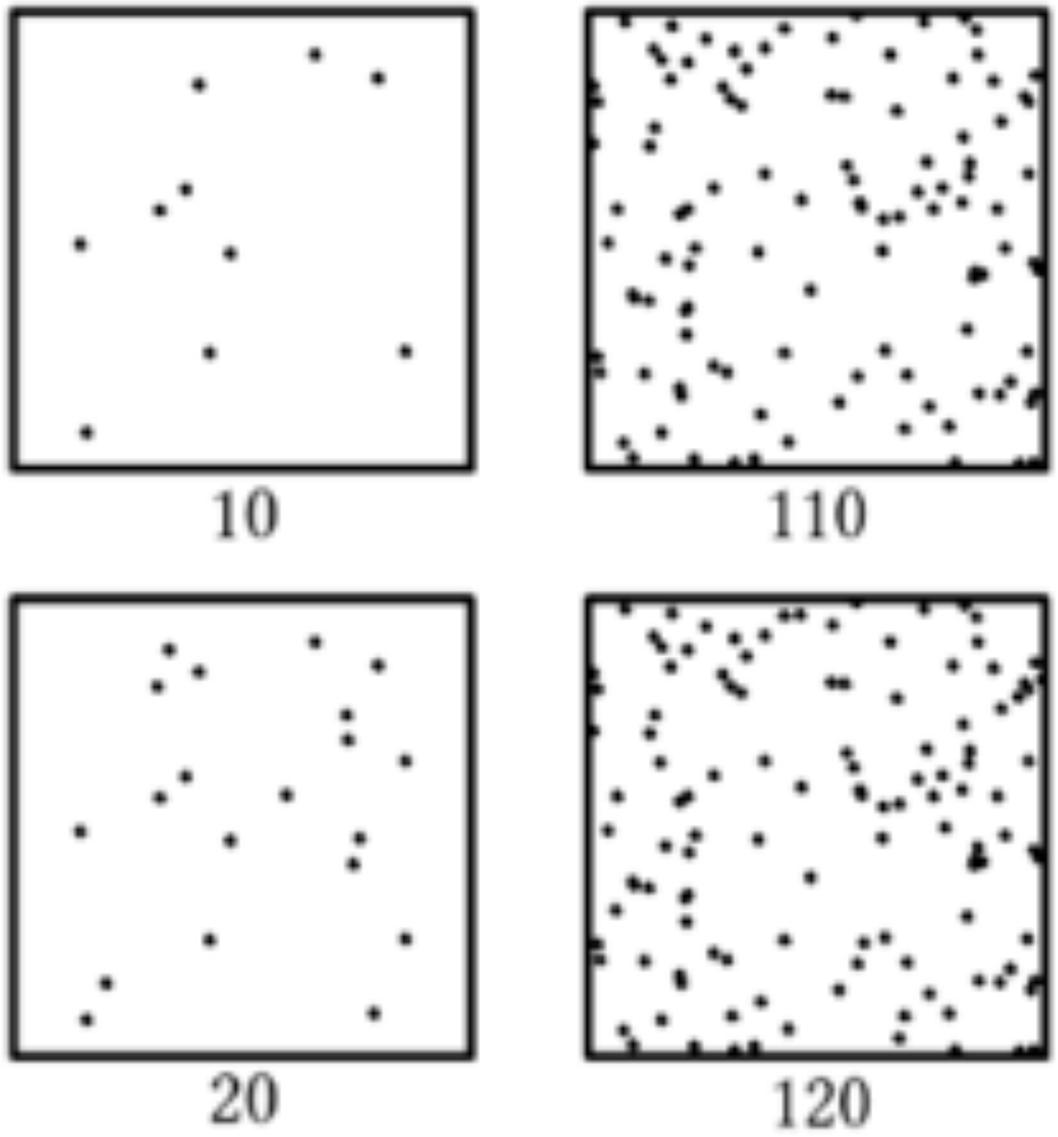
DETECTING BRIGHTNESS

(128, 128, 128)

(144, 144, 144)

Which is brighter?

JUST NOTICEABLE DIFFERENCES



JUST NOTICEABLE DIFFERENCES

JND (Weber's Law)

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

Ratios more important than magnitude

This is the smallest change in stimuli that can be perceived.

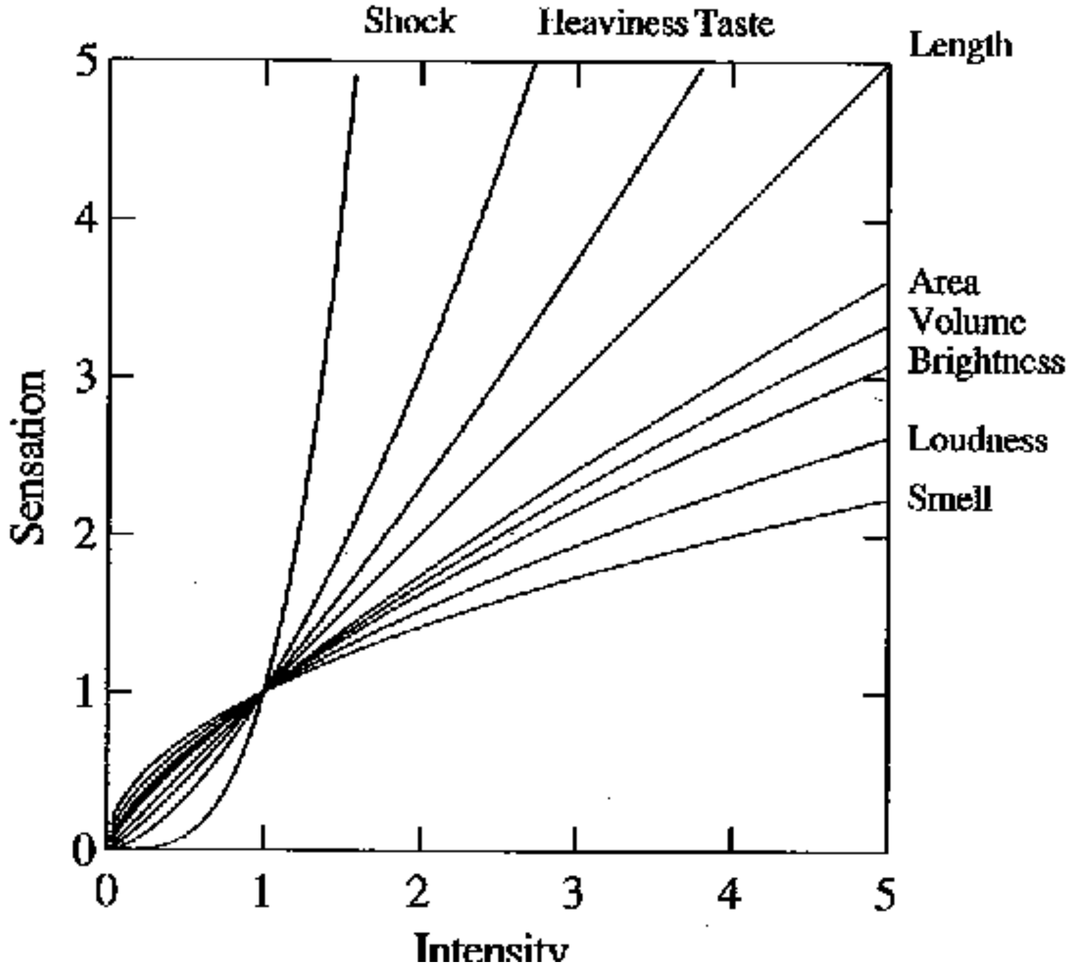
Most continuous variations perceived in discrete steps

STEVEN'S POWER LAW

$$S = I^p$$

p < 1 : underestimate

p > 1 : overestimate



relationship in psychophysics between an increased intensity or strength in a physical stimulus and the perceived magnitude

EXPONENTS OF POWER LAW

Sensation	*Exponent*
Loudness	*0.6*
Brightness	*0.33*
Smell	*0.55 (Coffee) - 0.6 (Heptane)*
Taste	*0.6 (Saccharine) -1.3 (Salt)*
Temperature	*1.0 (Cold) – 1.6 (Warm)*
Vibration	*0.6 (250 Hz) – 0.95 (60 Hz)*
Duration	*1.1*
Pressure	*1.1*
Heaviness	*1.45*
Electic Shock	*3.5*

SUMMARY

We create visualizations to

Record information

Support reasoning about the information

Convey information to others

Choose the right mark for your data

Position good for N, O, Q, but Hue best only for N

With careful design it is possible to display many dimensions at once


BREATHE