Data Visualization

Dec 2017

Contents

- What is data visualization?
- Why bother?
- Design critiques
- Importance of design
- Visual Variables to Charts to Networks to High Dimensional Data

Visualization

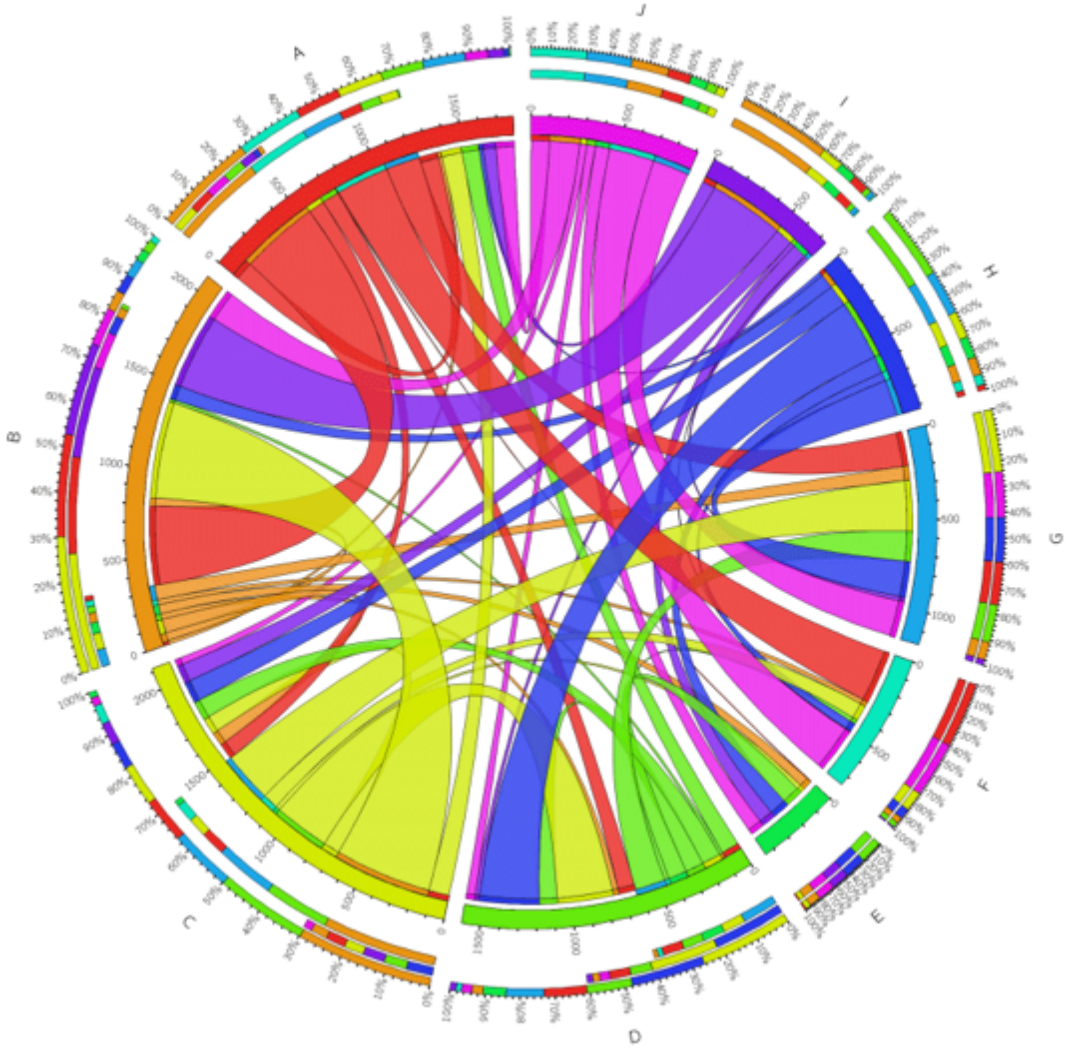
noun vi·su·al·i·za·tion \ˌvi-zhə-wə-lə-ˈzā-shən, ˌvi-zhə-lə-, ˌvizh-wə-lə-\

1. formation of mental visual images
2. the act or process of interpreting in visual terms or of putting into visible form
3. the process of making an internal organ or part visible by the introduction (as by swallowing) of a radiopaque substance followed by radiography

Source: Merriam-Webster dictionary

(Data) Visualization

To convey information through graphical representations of data



Goals of visualization

- **Record** information
- **Analyze** data to support decision making
- **Communicate** information to others

Fig. 18.—English Pouter.

Fig. 19.—English Carrier.

Fig. 20.—English Fort.

Fig. 21.—The Rock Pigeon, or Columba livia,
The parent-form of all domesticated Pigeons.

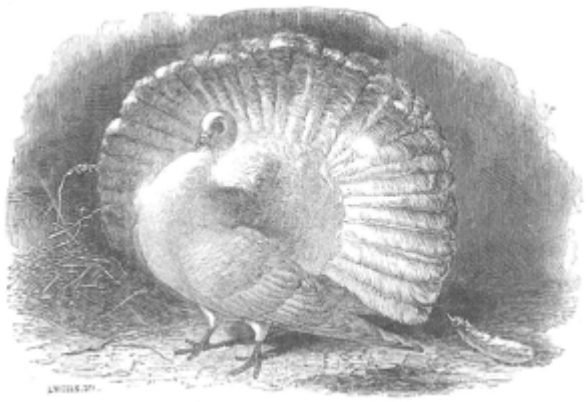


Fig. 22.—English Fantail.

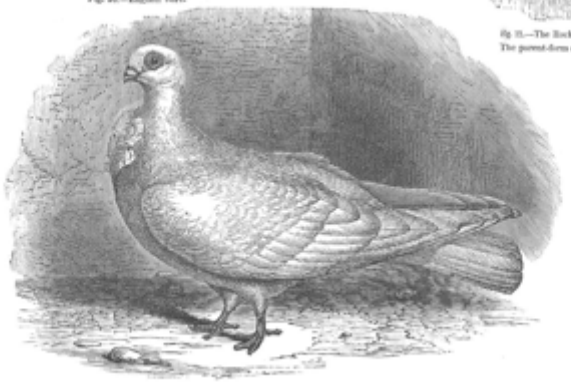
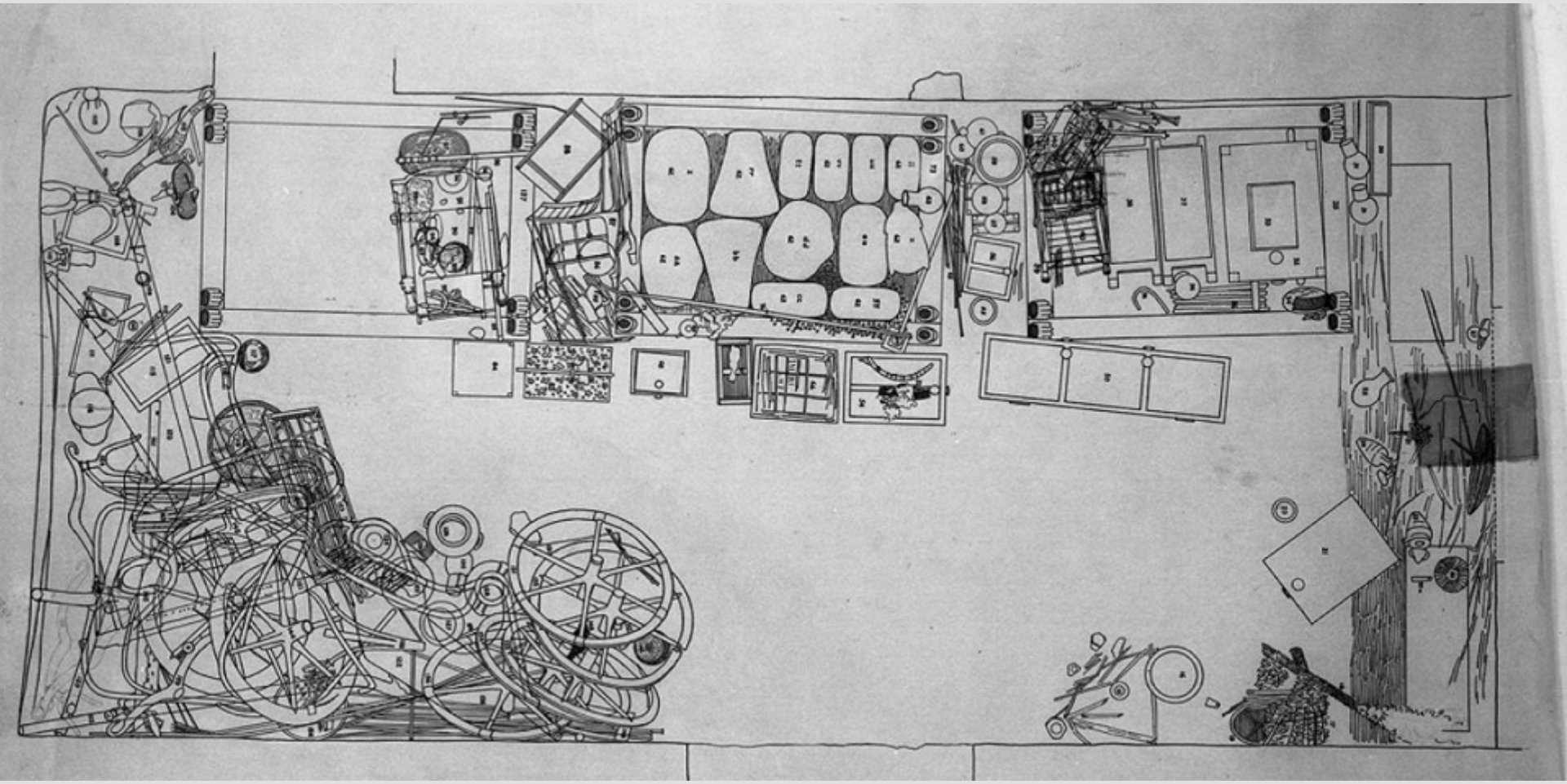
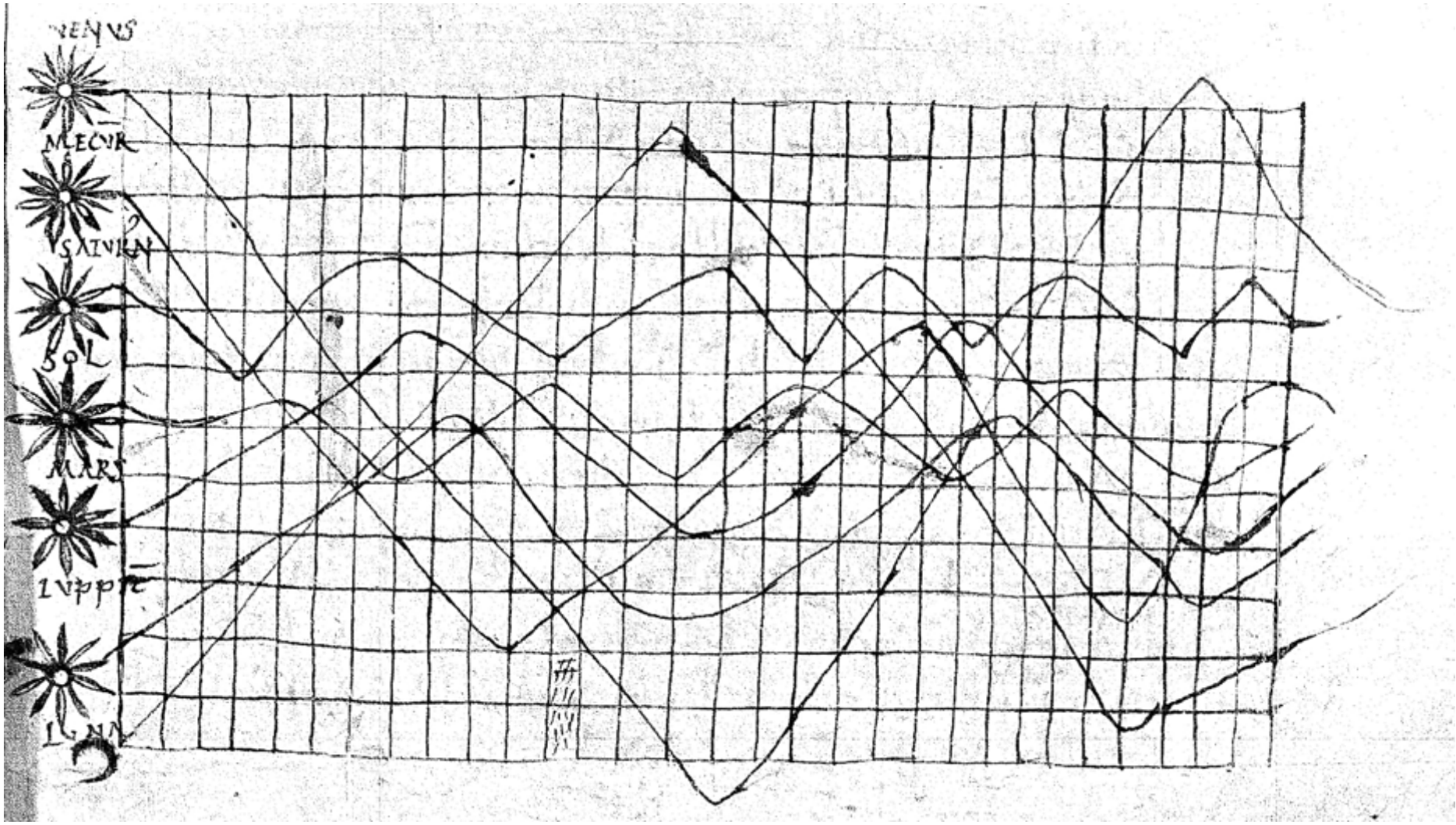
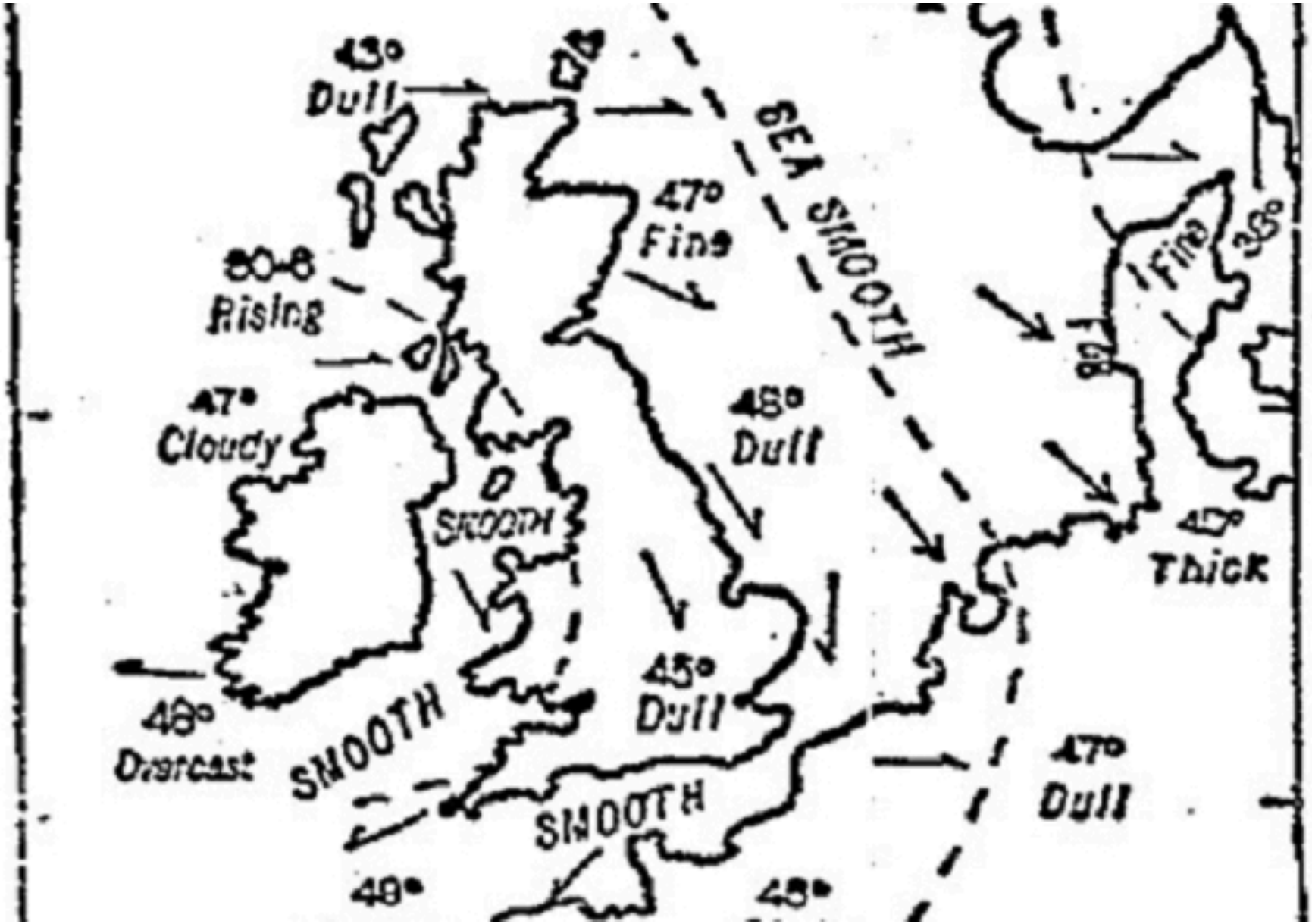


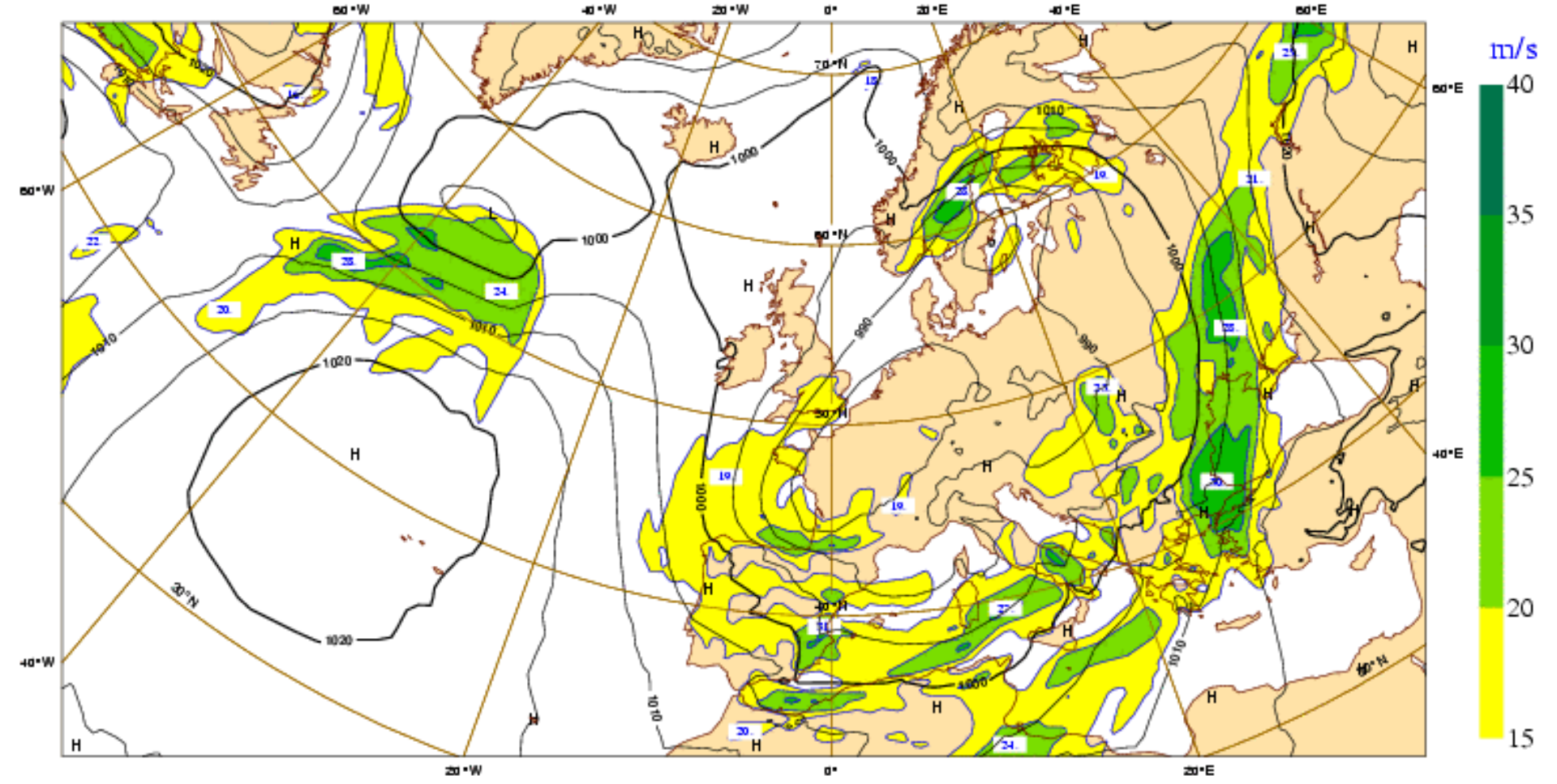
Fig. 23.—African Owl.

Fig. 24.—Short-faced English Tumbler.

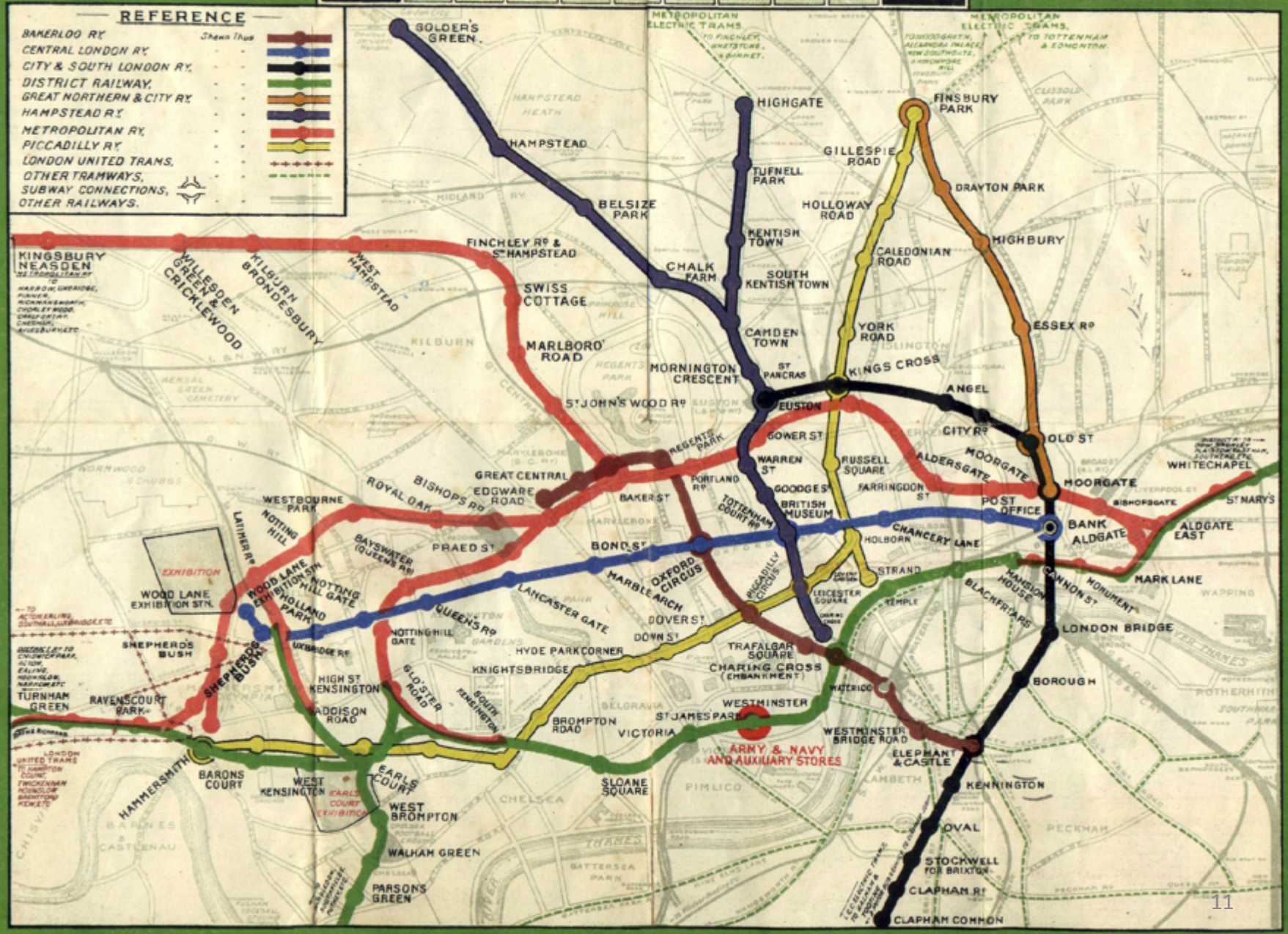


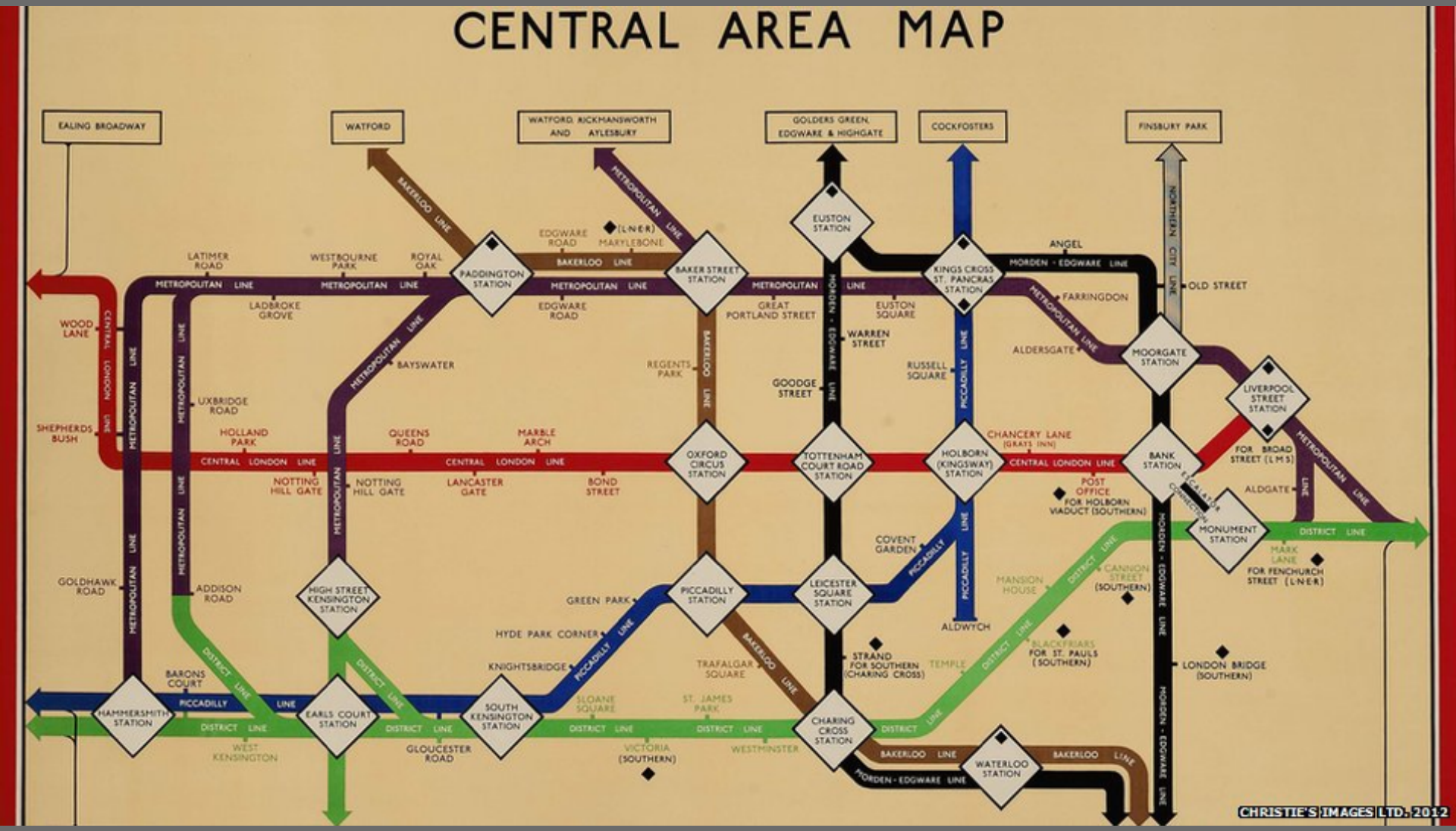

VENVS
MERCVR
SATVRN
SOL
MARS
IVPPR
LVNA

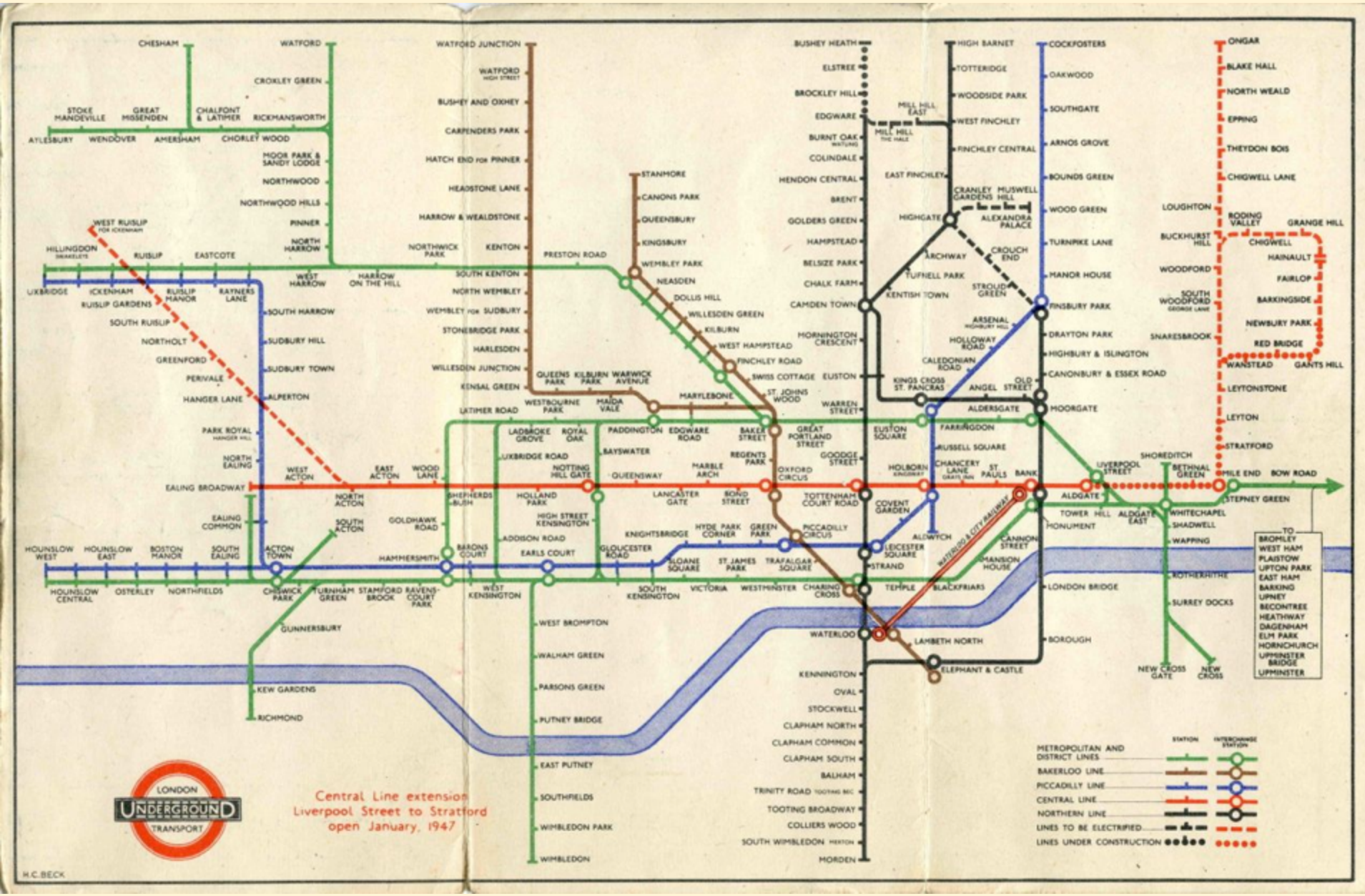

43°
Dull
SEA SMOOTH
47°
Fine
30.6
Rising
47°
Cloudy
45°
Dull
SMOOTH
Fine
Thick
45°
Dull
48°
Overcast
SMOOTH
47°
Dull
SMOOTH

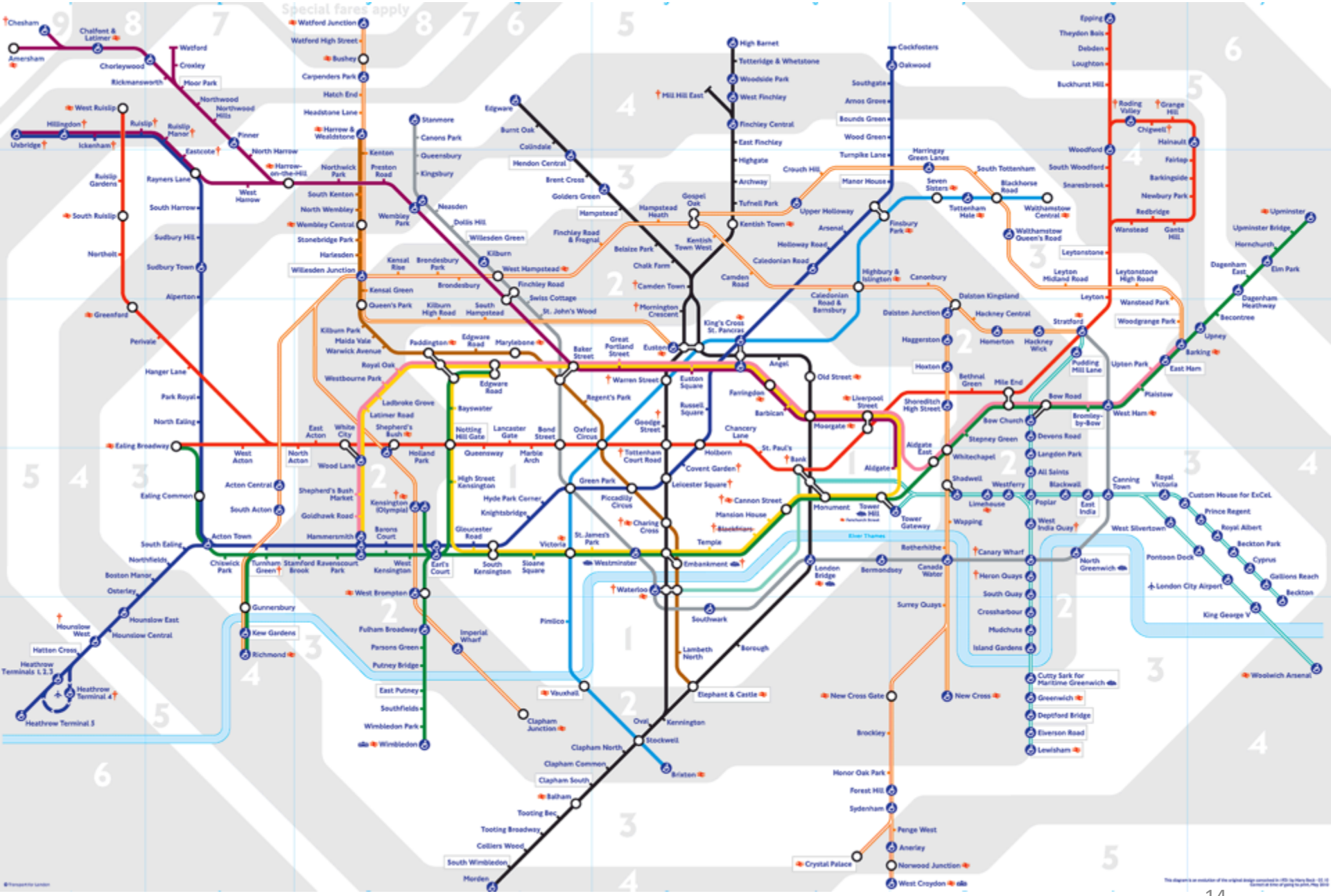

Wednesday 10 November 2010 00UTC ©ECMWF Analysis t+000 VT: Wednesday 10 November 2010 00UTC
Surface: Mean sea level pressure / 850-hPa wind speed
m/s
40
35
30
25
20
15

LONDON UNDERGROUND RAILWAYS




CENTRAL AREA MAP
EALING BROADWAY
WATFORD
WATFORD, RICKMANSWORTH AND AYLESBURY
GOLDERS GREEN, EDGWARE & HIGHGATE
COCKFOSTERS
FINSBURY PARK
WOOD LANE
SHEPHERDS BUSH
GOLDHAWK ROAD
BARONS COURT
HAMMERSMITH STATION
ADDISON ROAD
WEST KENSINGTON
EARLS COURT STATION
HIGH STREET KENSINGTON STATION
GLOUCESTER ROAD
SOUTH KENSINGTON STATION
KNIGHTSBRIDGE
HYDE PARK CORNER
GREEN PARK
PICCADILLY STATION
OXFORD CIRCUS STATION
TROTTENHAM COURT ROAD STATION
LEICESTER SQUARE STATION
CHARING CROSS STATION
TRAFALGAR SQUARE
STRAND FOR SOUTHERN (CHARING CROSS)
SLOANE SQUARE
ST. JAMES PARK
VICTORIA (SOUTHERN)
WESTMINSTER
WATERLOO STATION
HOLBORN (KINGSWAY) STATION
ALDWYCH
COVENT GARDEN
MANSION HOUSE
BLACKFRIARS FOR ST. PAULS (SOUTHERN)
TEMPLE
CANNON STREET (SOUTHERN)
LONDON BRIDGE (SOUTHERN)
BANK STATION
POST OFFICE FOR HOLBORN VIADUCT (SOUTHERN)
MONUMENT STATION
MARK LANE FOR FENCHURCH STREET (L.N.E.R.)
ALDGATE
LIVERPOOL STREET STATION
FOR BROAD STREET (L.M.S.)
MOORGATE STATION
ALDERSGATE
OLD STREET
ANGEL
KINGS CROSS ST. PANCRAS STATION
FARRINGDON
EUSTON STATION
EUSTON SQUARE
GREAT PORTLAND STREET
WARREN STREET
GOODGE STREET
RUSSELL SQUARE
REGENTS PARK
BAKER STREET STATION
PADDINGTON STATION
EDGWARE ROAD
MARYLEBONE (L.N.E.R.)
LADBROKE GROVE
LATIMER ROAD
WESTBOURNE PARK
ROYAL OAK
BAYSWATER
UXBRIDGE ROAD
HOLLAND PARK
NOTTING HILL GATE
QUEENS ROAD
LANCASTER GATE
MARBLE ARCH
BOND STREET
CHANCERY LANE (GRAYS INN)
CENTRAL LONDON LINE
METROPOLITAN LINE
DISTRICT LINE
PICCADILLY LINE
BAKERLOO LINE
HAMMERSMITH & CITY LINE
NORTHERN CITY LINE
MORDEN - EDGWARE LINE
ESCALATOR CONNECTION
CHRISTIE'S IMAGES LTD. 2012


Central Line extension
Liverpool Street to Stratford
open January, 1947
LONDON UNDERGROUND TRANSPORT
H.C.BECK
METROPOLITAN AND DISTRICT LINES
BAKERLOO LINE
PICCADILLY LINE
CENTRAL LINE
NORTHERN LINE
LINES TO BE ELECTRIFIED
LINES UNDER CONSTRUCTION
STATION
INTERCHANGE STATION
TO
BROMLEY
WEST HAM
PLAISTOW
UPTON PARK
EAST HAM
BARKING
UPNEY
BECONTREE
HEATHWAY
DAGENHAM
ELM PARK
HORNCHURCH
UPMINSTER BRIDGE
UPMINSTER


Special fares apply
Chesham
Amersham
Chalfont & Latimer
Chorleywood
Rickmansworth
Watford
Croxley
Moor Park
Northwood
Northwood Hills
Pinner
North Harrow
Harrow-on-the-Hill
West Ruislip
Hillingdon
Uxbridge
Ickenham
Ruislip
Ruislip Manor
Eastcote
Ruislip Gardens
South Ruislip
Northolt
Greenford
Perivale
Hanger Lane
Park Royal
North Ealing
Ealing Broadway
Ealing Common
Acton Town
South Ealing
Northfields
Boston Manor
Osterley
Hounslow East
Hounslow Central
Hounslow West
Hatton Cross
Heathrow Terminals 1, 2, 3
Heathrow Terminal 4
Heathrow Terminal 5
Rayners Lane
South Harrow
Sudbury Hill
Sudbury Town
Alperton
West Harrow
Watford Junction
Watford High Street
Bushey
Carpenders Park
Hatch End
Headstone Lane
Harrow & Wealdstone
Kenton
Preston Road
Northwick Park
South Kenton
North Wembley
Wembley Central
Stonebridge Park
Harlesden
Willesden Junction
Wembley Park
Stanmore
Canons Park
Queensbury
Kingsbury
Neasden
Dollis Hill
Willesden Green
Kilburn
West Hampstead
Kensal Rise
Brondesbury Park
Brondesbury
Kensal Green
Queen's Park
Kilburn High Road
South Hampstead
Finchley Road
Swiss Cottage
St. John's Wood
Finchley Road & Frognal
Edgware
Burnt Oak
Colindale
Hendon Central
Brent Cross
Golders Green
Hampstead
Hampstead Heath
Belsize Park
Chalk Farm
Camden Town
Mornington Crescent
Camden Road
Gospel Oak
Kentish Town West
Kentish Town
Tufnell Park
Archway
Highgate
East Finchley
Finchley Central
Woodside Park
West Finchley
Totteridge & Whetstone
High Barnet
Mill Hill East
Crouch Hill
Upper Holloway
Arsenal
Holloway Road
Caledonian Road
Caledonian Road & Barnsbury
Highbury & Islington
Canonbury
Dalston Kingsland
Dalston Junction
Hackney Central
Hackney Wick
Haggerston
Hoxton
Shoreditch High Street
Old Street
Angel
King's Cross St. Pancras
Euston
Great Portland Street
Warren Street
Euston Square
Russell Square
Ferringdon
Barbican
Liverpool Street
Moorgate
Bethnal Green
Mile End
Bow Road
Bow Church
Devons Road
Stepney Green
Langdon Park
All Saints
Whitechapel
Aldgate East
Aldgate
Shadwell
Westferry
Blackwall
Poplar
East India
Limehouse
Wapping
West India Quay
Canary Wharf
Heron Quays
South Quay
Crossharbour
Mudchute
Island Gardens
Cutty Sark for Maritime Greenwich
Greenwich
Deptford Bridge
Elverson Road
Lewisham
Canning Town
Royal Victoria
Custom House for ExCeL
Prince Regent
Royal Albert
Beckton Park
Cyprus
Gallions Reach
Beckton
Pontoon Dock
London City Airport
King George V
Woolwich Arsenal
North Greenwich
West Silvertown
Rotherhithe
Canada Water
Surrey Quays
New Cross
New Cross Gate
Brockley
Honor Oak Park
Forest Hill
Sydenham
Penge West
Anerley
Norwood Junction
West Croydon
Crystal Palace
Bermondsey
London Bridge
Borough
Southwark
Elephant & Castle
Lambeth North
Kennington
Oval
Stockwell
Brixton
Clapham North
Clapham Common
Clapham South
Balham
Tooting Bec
Tooting Broadway
Colliers Wood
South Wimbledon
Morden
Clapham Junction
Vauxhall
Pimlico
Victoria
St. James's Park
Westminster
Embankment
Waterloo
Charing Cross
Piccadilly Circus
Green Park
Leicester Square
Covent Garden
Holborn
Tottenham Court Road
Goodge Street
Regent's Park
Oxford Circus
Bond Street
Marble Arch
Lancaster Gate
Queensway
Notting Hill Gate
Bayswater
Ladbroke Grove
Latimer Road
Westbourne Park
Royal Oak
Maida Vale
Warwick Avenue
Paddington
Edgware Road
Marylebone
Baker Street
Edgware Road
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Earl's Court
West Kensington
Barons Court
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Goldhawk Road
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Wood Lane
Shepherd's Bush
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Monument
Tower Hill
Tower Gateway
Blackfriars
Temple
St. Paul's
Bank
Chancery Lane
Holborn
Gunnersbury
Kew Gardens
Richmond
Fulham Broadway
Parsons Green
Putney Bridge
East Putney
Southfields
Wimbledon Park
Wimbledon
West Brompton
Imperial Wharf
Gunnersbury
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Gloucester Road
South Kensington
Sloane Square
Knightsbridge
Hyde Park Corner
Mansion House
Cannon Street
Monument
Tower Hill
Tower Gateway
Blackfriars
Temple
St. Paul's
Bank
Chancery Lane
Holborn
Gunnersbury
Kew Gardens
Richmond
Fulham Broadway
Parsons Green
Putney Bridge
East Putney
Southfields
Wimbledon Park
Wimbledon
West Brompton
Imperial Wharf
Epping
Theydon Bois
Debden
Loughton
Buckhurst Hill
Roding Valley
Grange Hill
Chigwell
Hainault
Woodford
South Woodford
Snaresbrook
Fairlop
Barkingside
Newbury Park
Redbridge
Wanstead
Gants Hill
Leytonstone
Leyton Midland Road
Leytonstone High Road
Wanstead Park
Woodgrange Park
Leyton
Stratford
Pudding Mill Lane
Upton Park
East Ham
Barking
Upney
Becontree
Dagenham Heathway
Dagenham East
Elm Park
Hornchurch
Upminster Bridge
Upminster
Harrington Green Lanes
Seven Sisters
South Tottenham
Tottenham Hale
Blackhorse Road
Walthamstow Central
Walthamstow Queen's Road
Manor House
Turnpike Lane
Wood Green
Bounds Green
Arnos Grove
Southgate
Oakwood
Cockfosters
Finsbury Park
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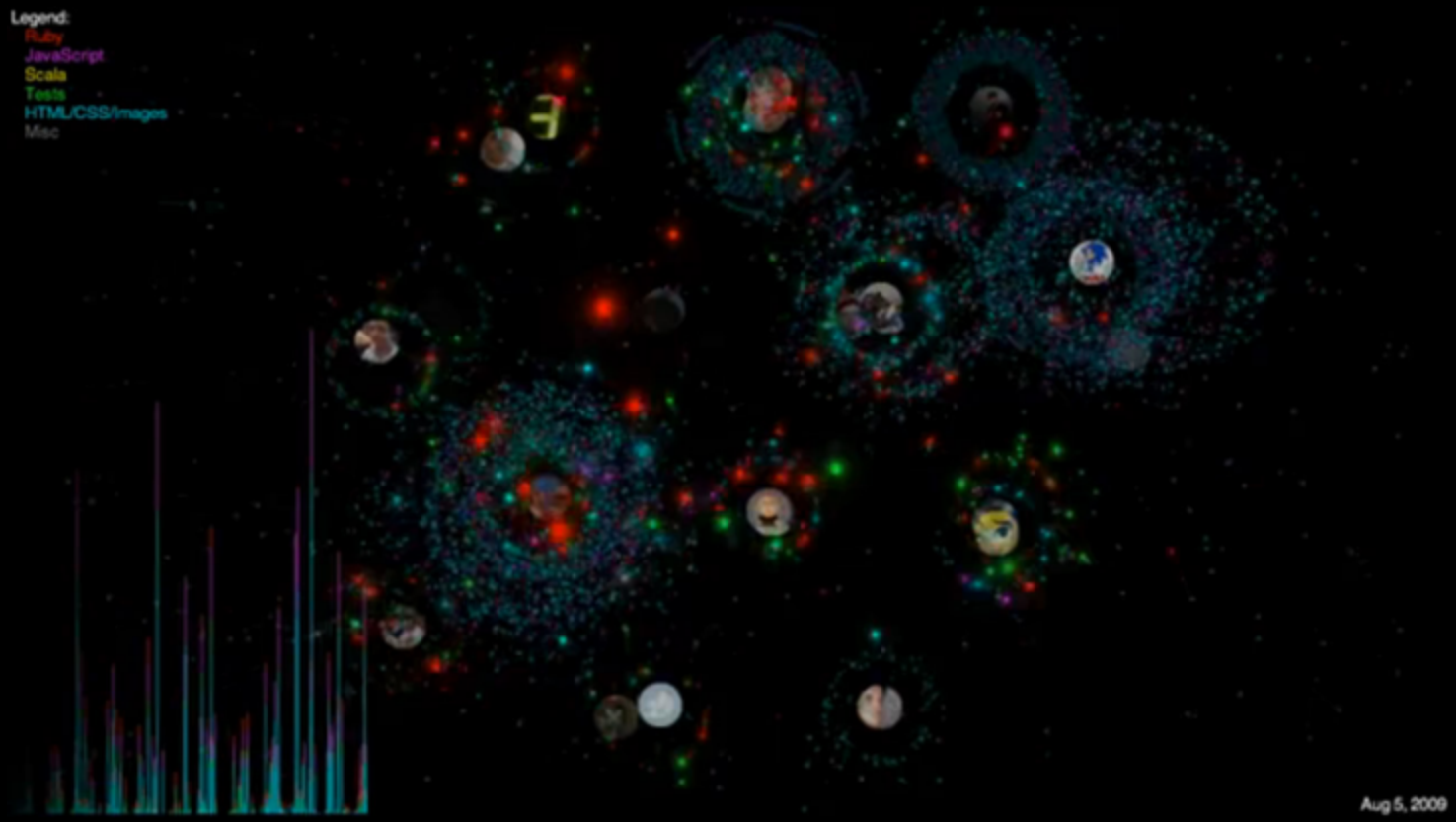
Richmond
Fulham Broadway
Parsons Green
Putney Bridge
East Putney
Southfields
Wimbledon Park
Wimbledon
West Brompton
Imperial Wharf

The Best Stats You Have Ever Seen

https://www.youtube.com/watch?v=usdJgEwMinM

Storytelling

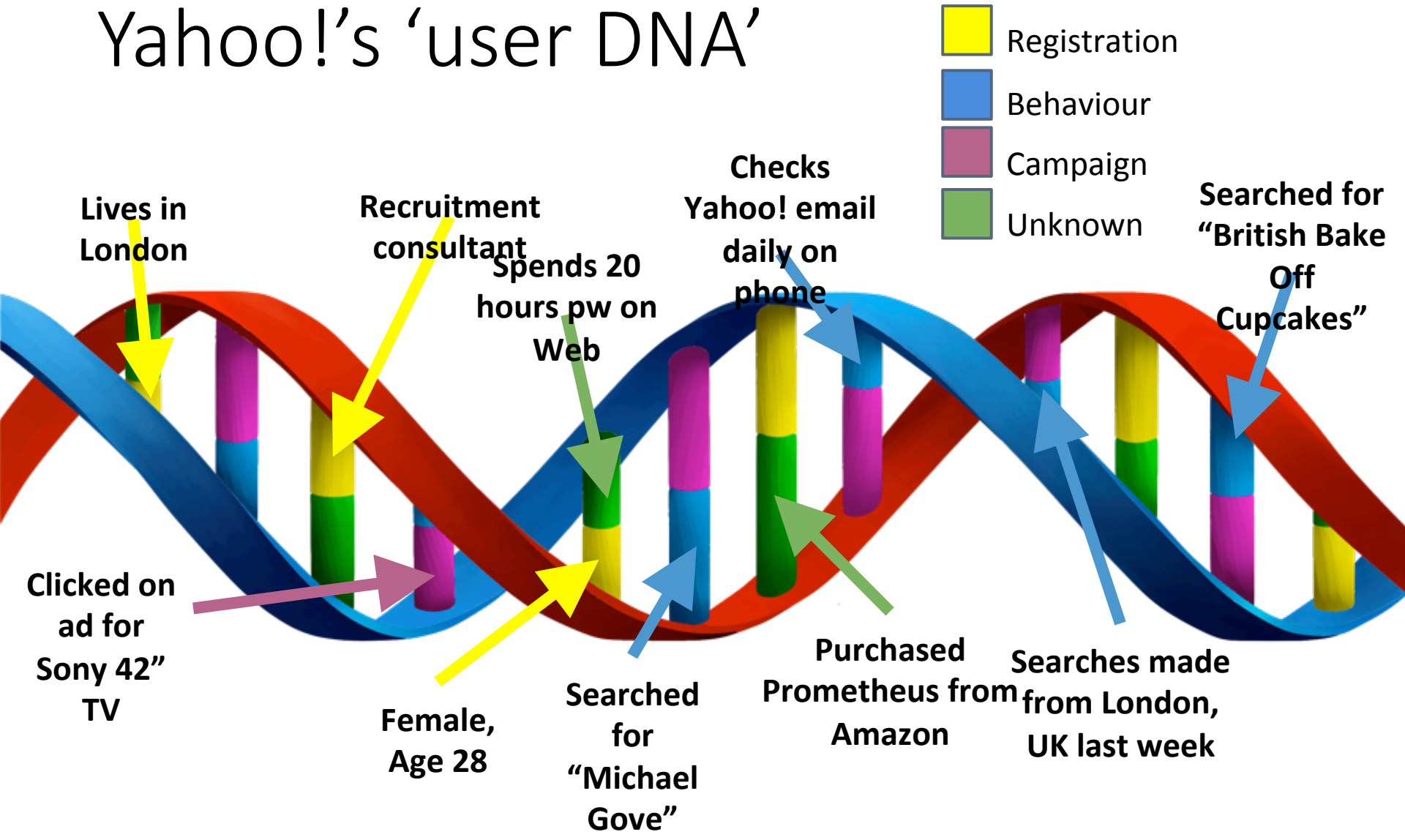


https://vimeo.com/9225227

Why data visualization?

- Big data
- Limits to cognition/understanding
- Visual queries are easier to understand (even with summarized statistics, abstract visual cues are fast)

Yahoo!’s ‘user DNA’



Example borrowed/modified from Usama Fayyad (CDO, Barclays)

Registration Behaviour Campaign Unknown

Lives in London

Recruitment consultant

Female, Age 28

Searched for "Michael Gove"

Checks Yahoo! email daily on phone

Searches made from London, UK last week

Searched for "British Bake Off Cupcakes"

Clicked on ad for Sony 42" TV

Spends 20 hours pw on Web

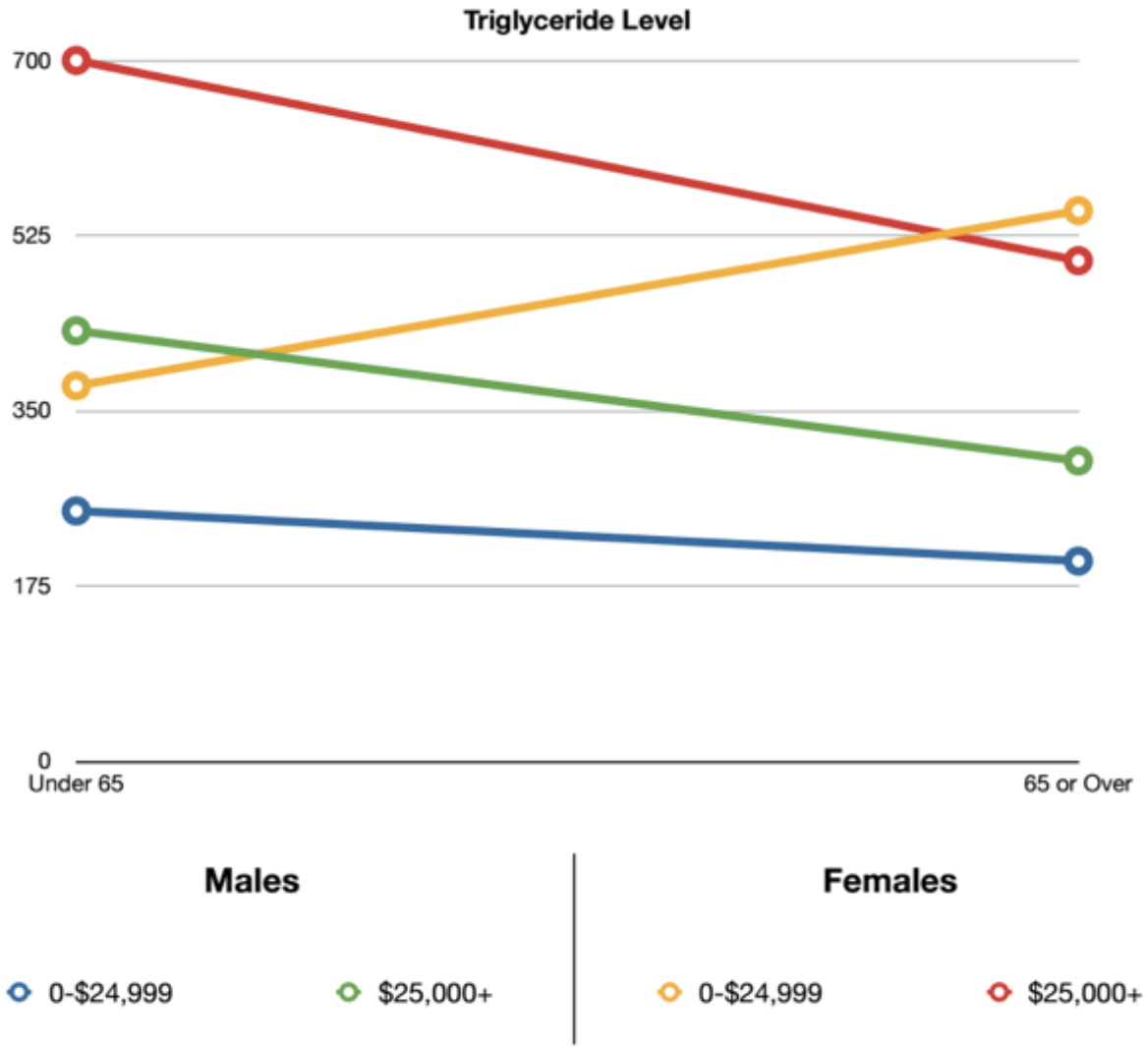
Purchased Prometheus from Amazon

Limits to cognition

- Which gender or income level group shows different effects of age on cholesterol levels?

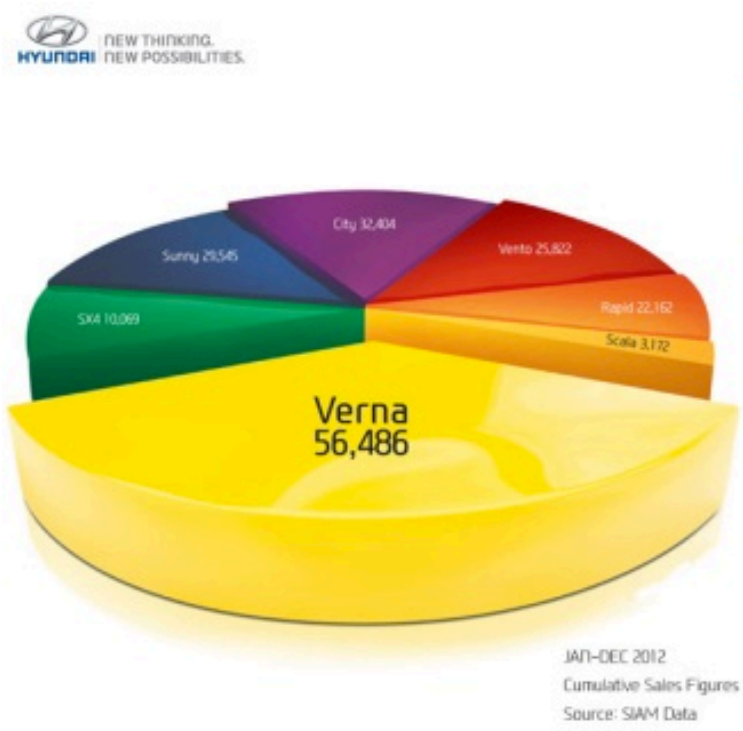
	Males		Females	
Income Group	Under 65	65 or Over	Under 65	65 or Over
0-$24,999	250	200	375	550
$25,000+	430	300	700	500

Limits to cognition

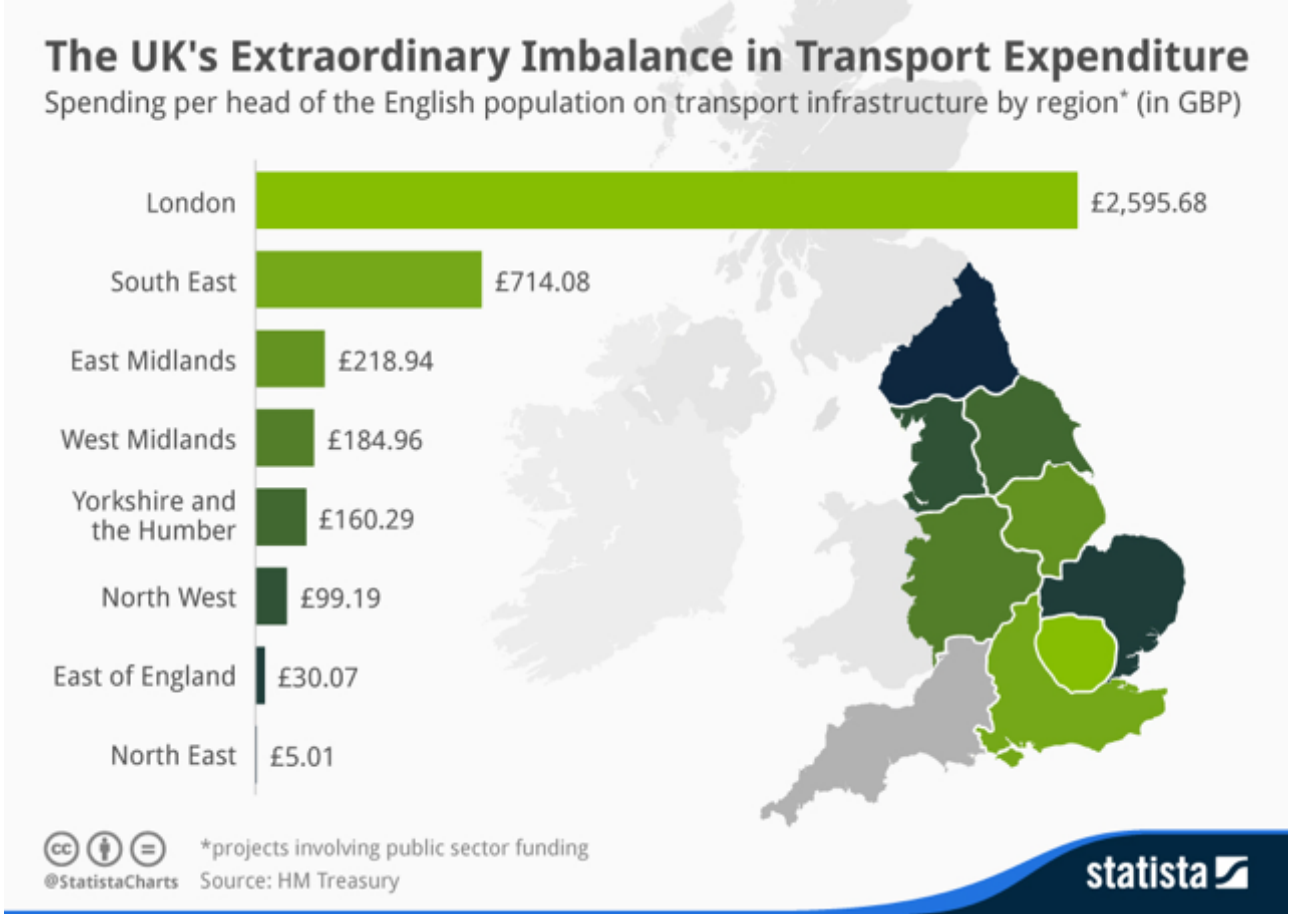


Critique

Critique

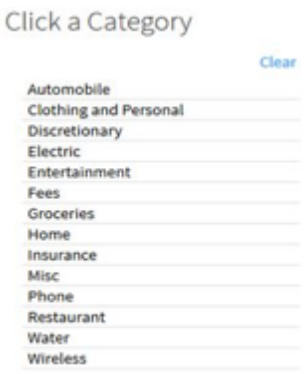

HYUNDAI
NEW THINKING.
NEW POSSIBILITIES.
The chartbuster rules.
The Verna stays the undisputed No. 1 in its segment.
With its inimitable styling and superior design, the Verna has emerged as the largest selling car in its segment by a large margin. And it's not just the car that's made us the leader, it's also discerning people like you. No wonder the competition's been left behind. Far far behind.
City 32,404
Sunny 29,545
Vento 25,822
Rapid 22,162
SX4 10,069
Scala 3,172
Verna
56,486
JAN-DEC 2012
Cumulative Sales Figures
Source: SIAM Data
The new FLUIDIC
VERNA
It sets you thinking

Critique

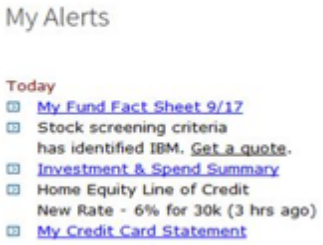

The UK's Extraordinary Imbalance in Transport Expenditure
Spending per head of the English population on transport infrastructure by region* (in GBP)
London
£2,595.68
South East
£714.08
East Midlands
£218.94
West Midlands
£184.96
Yorkshire and the Humber
£160.29
North West
£99.19
East of England
£30.07
North East
£5.01
*projects involving public sector funding
@StatistaCharts
Source: HM Treasury
statista

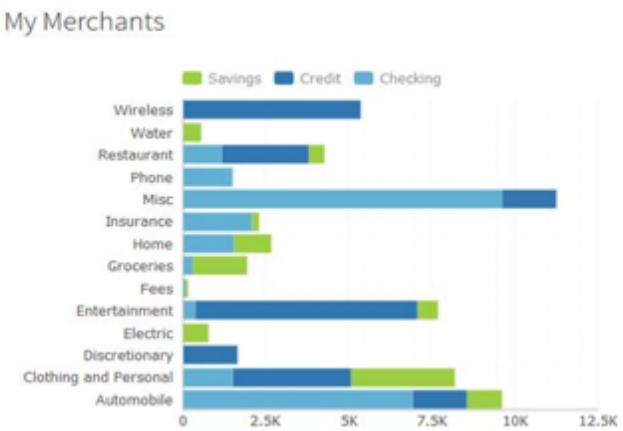
Critique

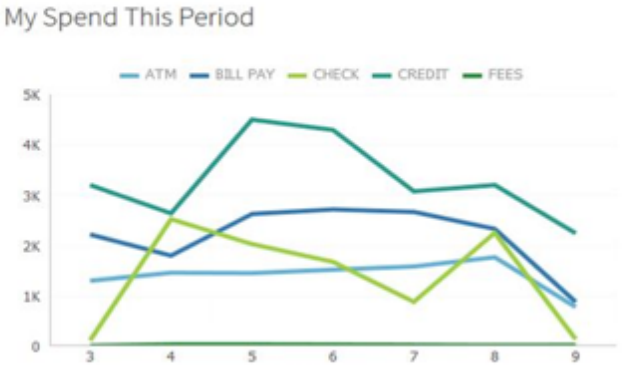
Critique

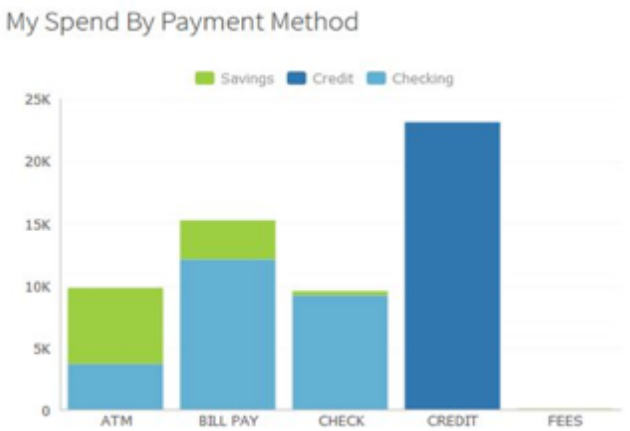

Click a Category
Clear
Automobile
Clothing and Personal
Discretionary
Electric
Entertainment
Fees
Groceries
Home
Insurance
Misc
Phone
Restaurant
Water
Wireless

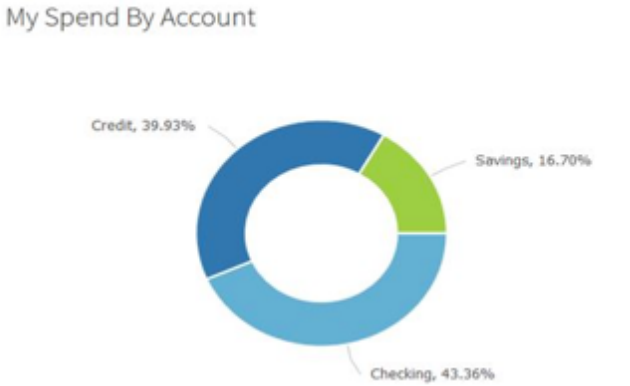

Month Range
3
9


My Alerts
Today
My Fund Fact Sheet 9/17
Stock screening criteria has identified IBM. Get a quote.
Investment & Spend Summary
Home Equity Line of Credit New Rate - 6% for 30k (3 hrs ago)
My Credit Card Statement

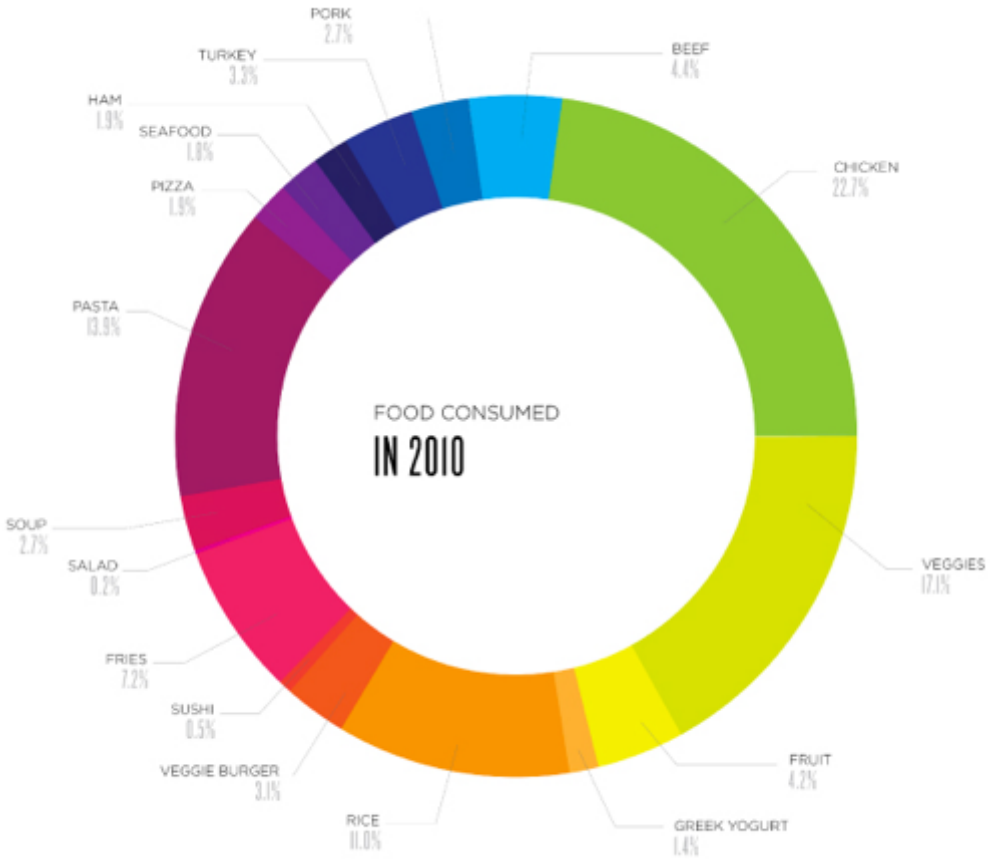

My Merchants
Savings
Credit
Checking
Wireless
Water
Restaurant
Phone
Misc
Insurance
Home
Groceries
Fees
Entertainment
Electric
Discretionary
Clothing and Personal
Automobile
0
2.5K
5K
7.5K
10K
12.5K


My Spend This Period
ATM
BILL PAY
CHECK
CREDIT
FEES
5K
4K
3K
2K
1K
0
3
4
5
6
7
8
9

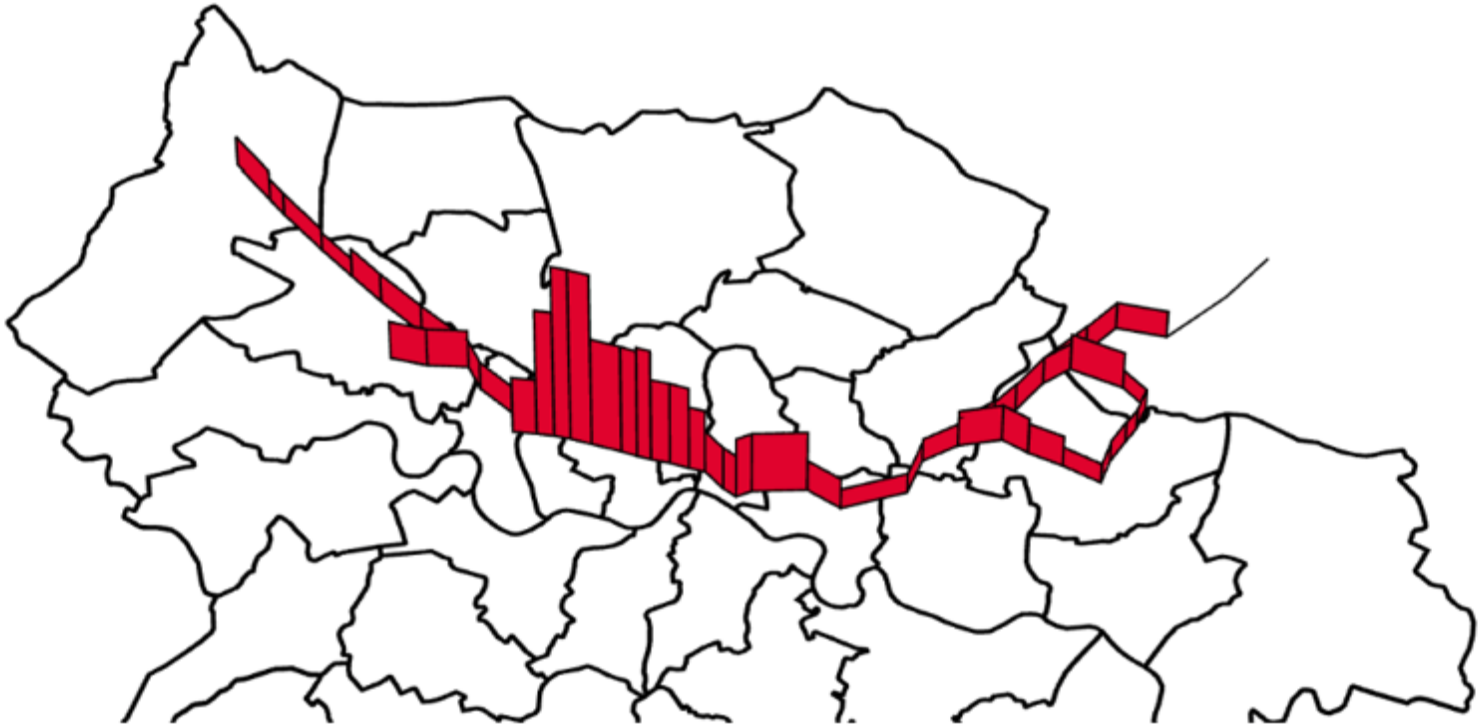

My Spend By Payment Method
Savings
Credit
Checking
25K
20K
15K
10K
5K
0
ATM
BILL PAY
CHECK
CREDIT
FEES


My Spend By Account
Credit, 39.93%
Savings, 16.70%
Checking, 43.36%

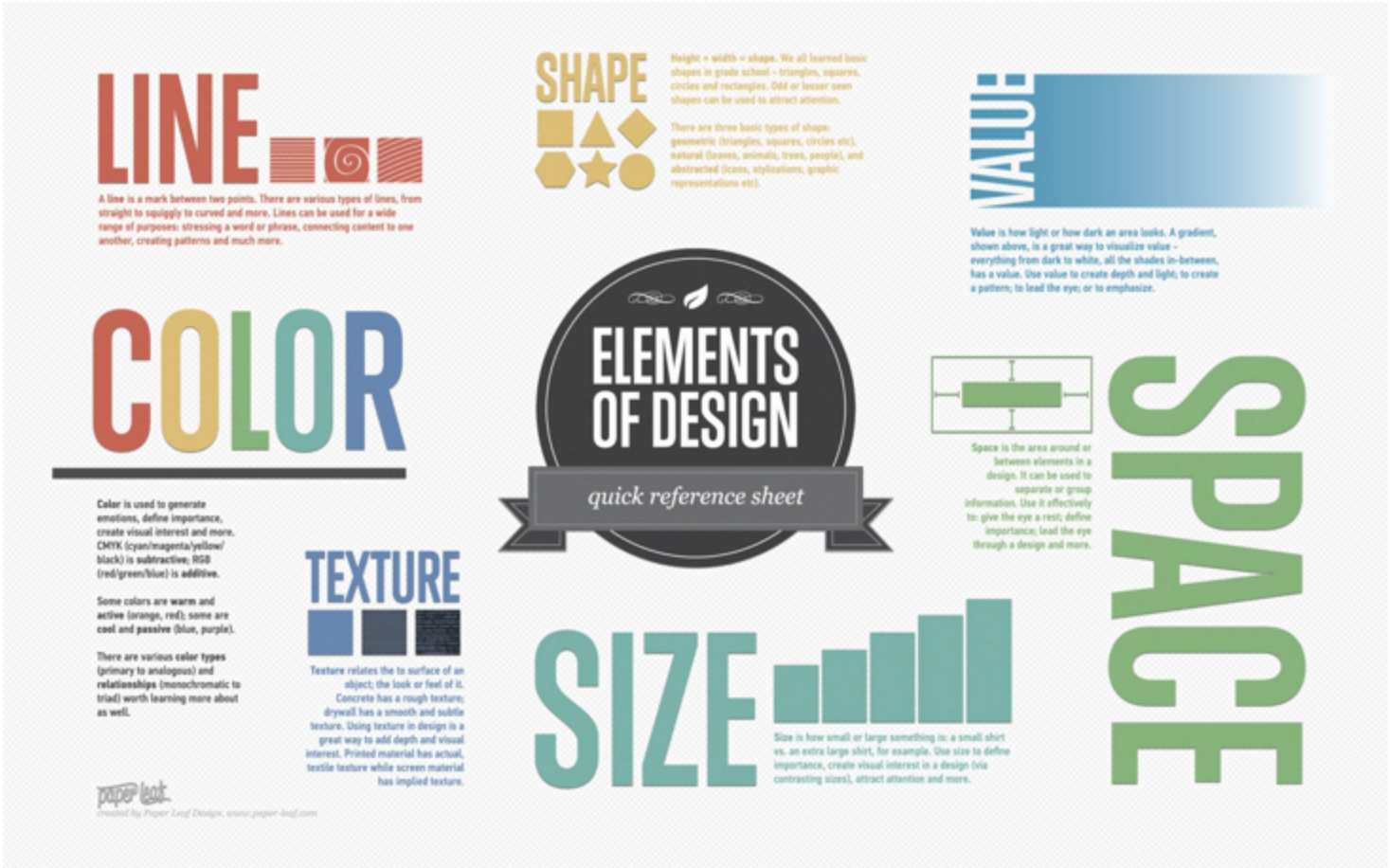
Critique


FOOD CONSUMED
IN 2010
PORK
2.7%
BEEF
4.4%
TURKEY
3.3%
HAM
1.9%
SEAFOOD
1.8%
CHICKEN
22.7%
PIZZA
1.9%
PASTA
13.8%
SOUP
2.7%
SALAD
0.2%
VEGGIES
17.1%
FRIES
7.2%
SUSHI
0.5%
FRUIT
4.2%
VEGGIE BURGER
3.1%
RICE
11.0%
GREEK YOGURT
1.4%

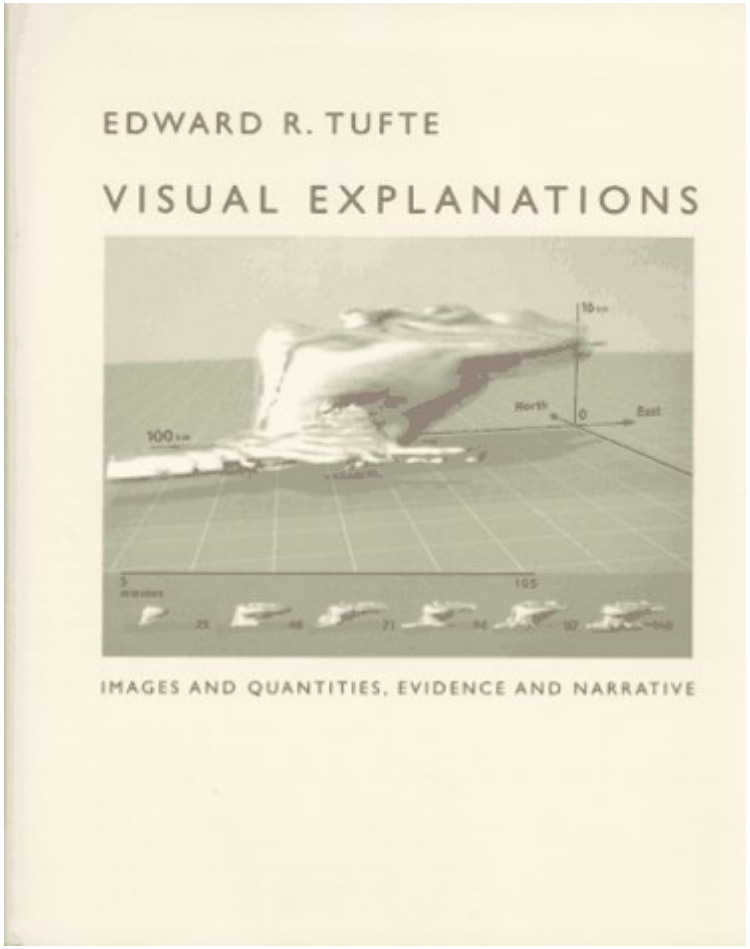
Critique

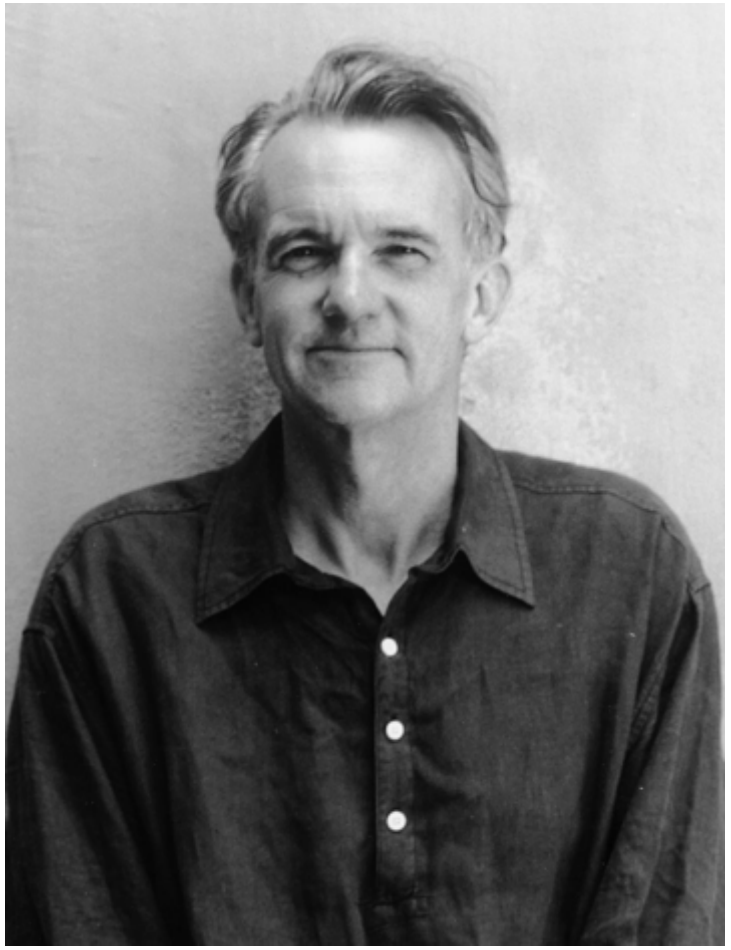


Importance of Design



Edward Tufte

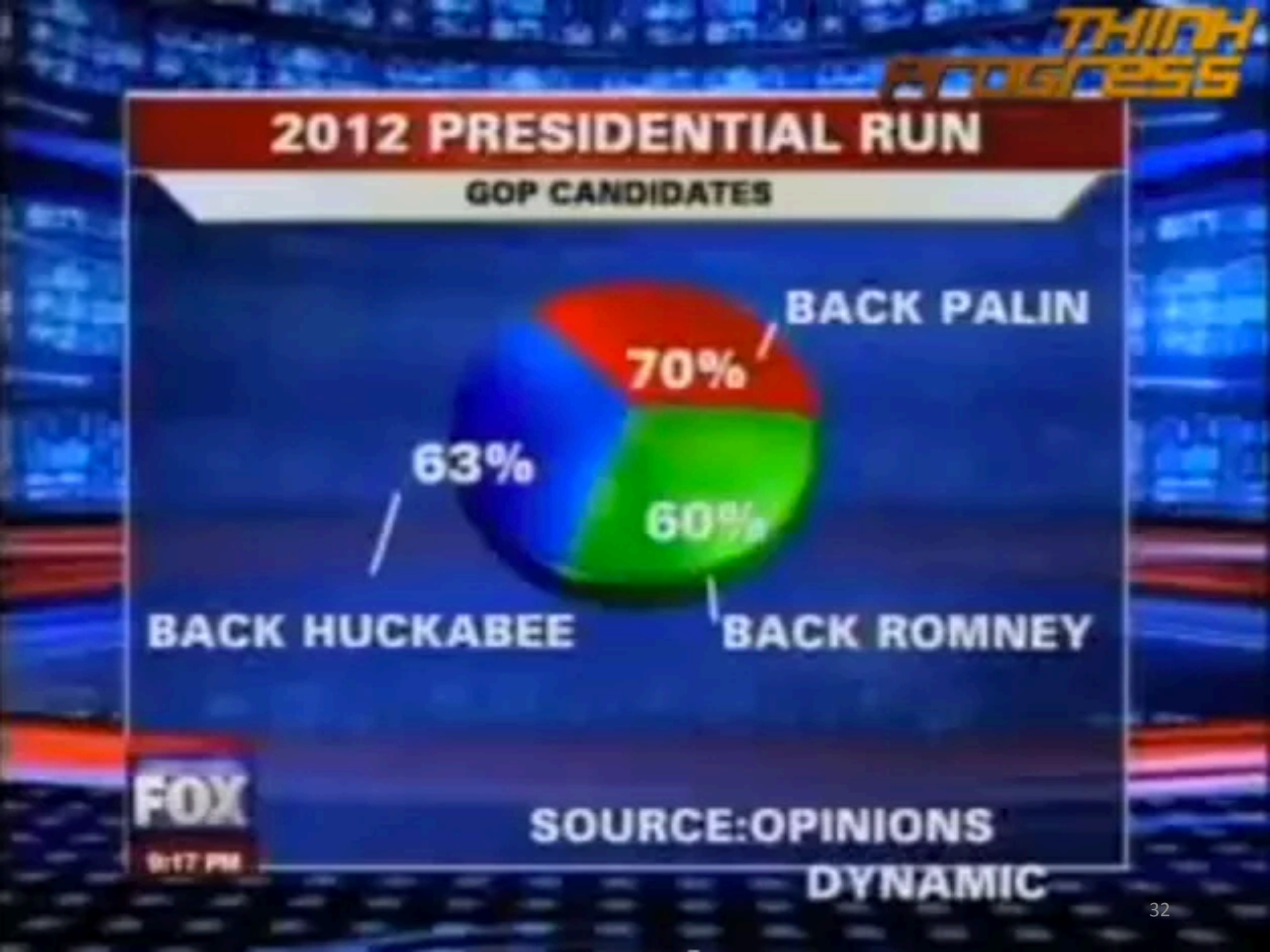




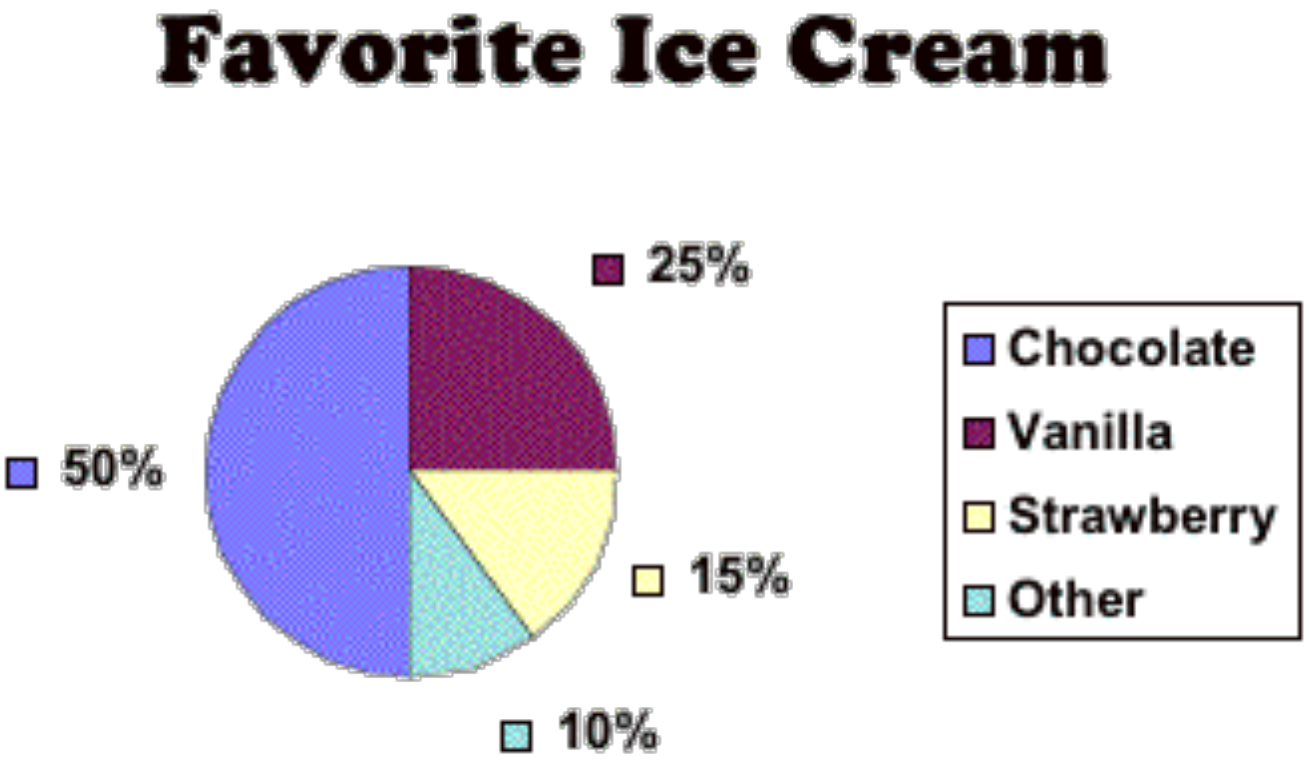
Design Principles

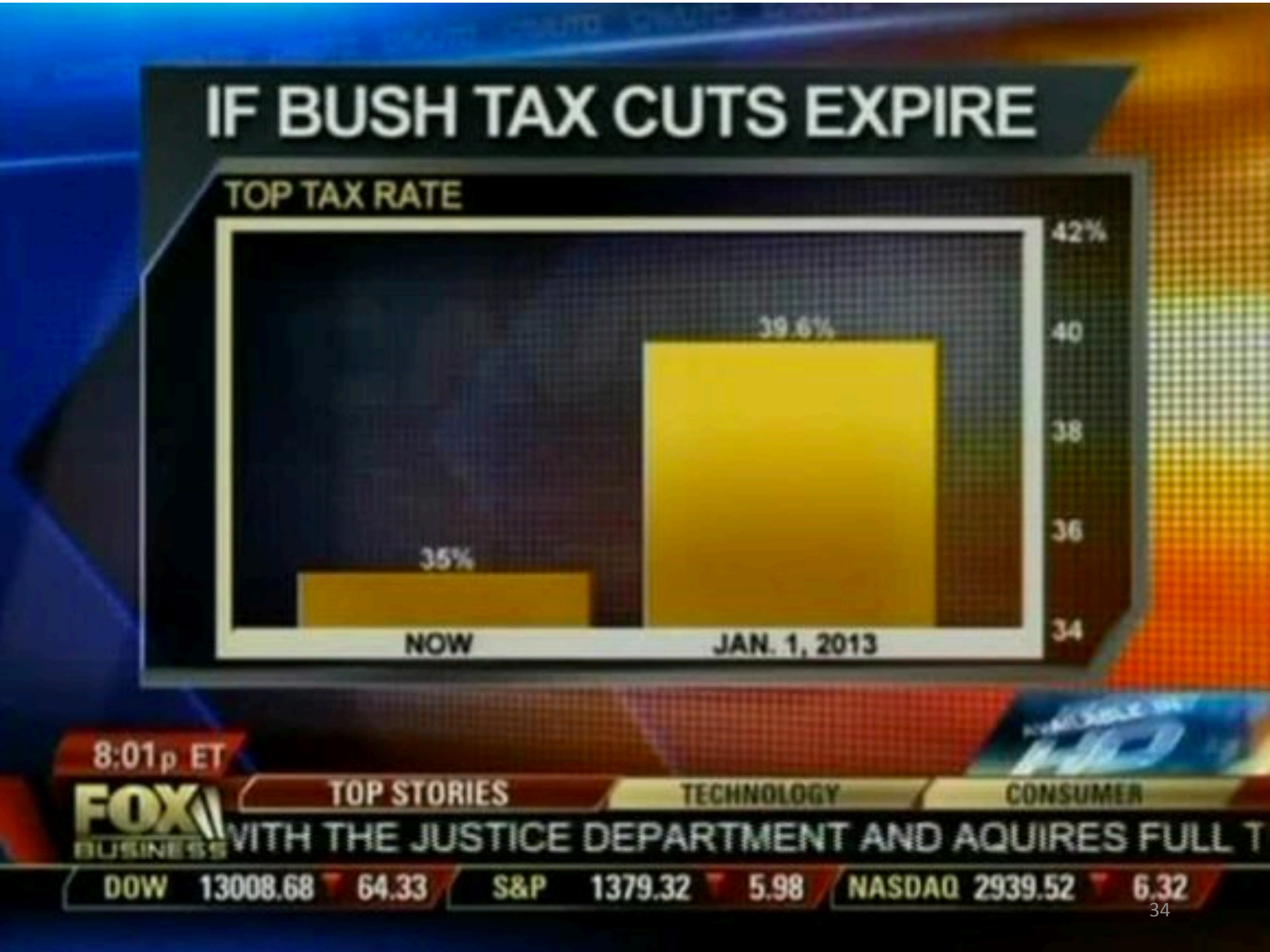
- Graphical integrity
  - Always tell the truth about the data
  - Use clear, detailed labels to defeat distortion and ambiguity
  - Show data variation, not design variation

- Design aesthetics
  - Be clear and precise
  - Maximize data-ink ratio (i.e. reduce redundant display of information)
  - Avoid chartjunk
  - Maximize data density

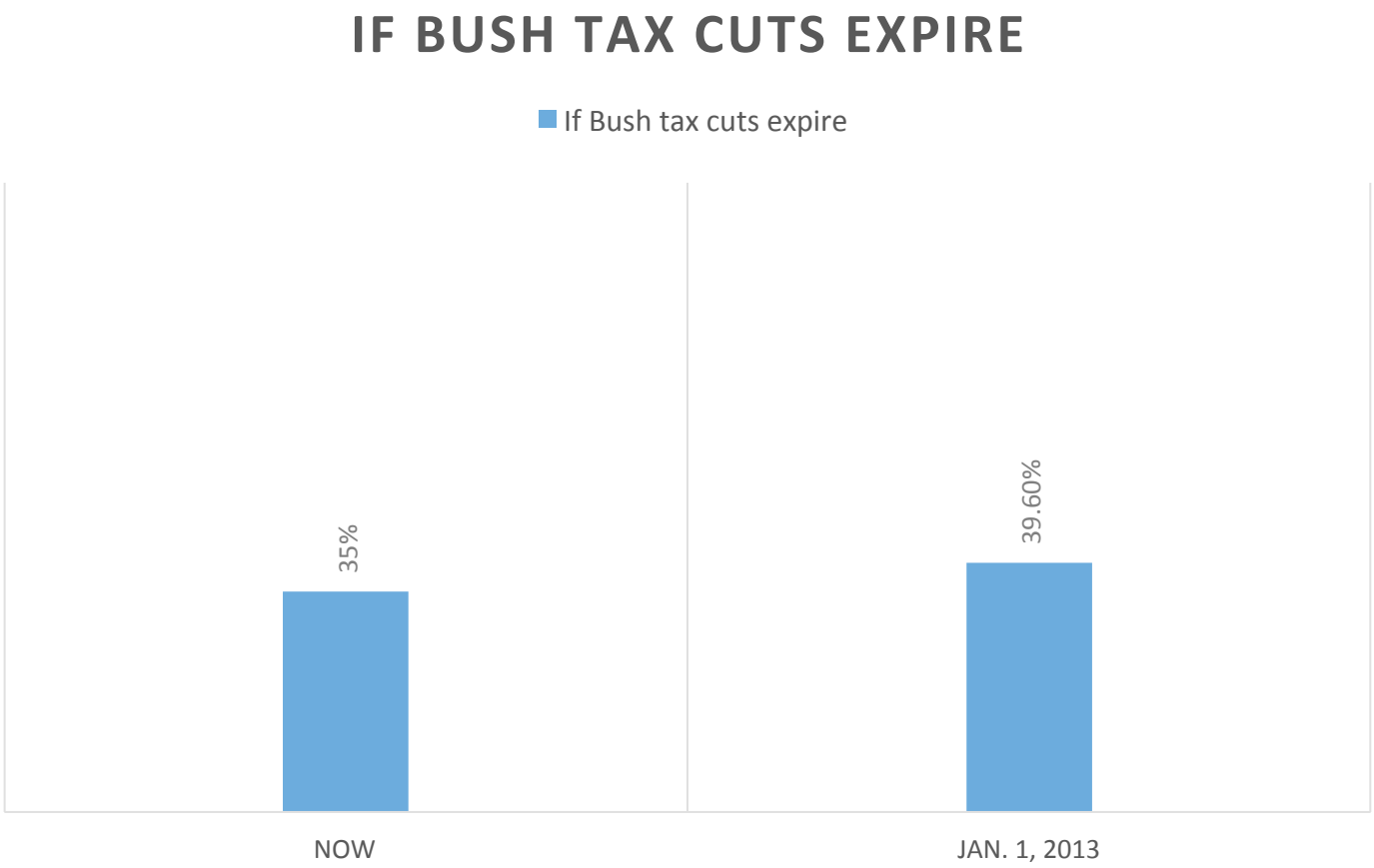

THINK PROGRESS
2012 PRESIDENTIAL RUN
GOP CANDIDATES
BACK PALIN
70%
63%
60%
BACK HUCKABEE
BACK ROMNEY
FOX
9:17 PM
SOURCE:OPINIONS DYNAMIC

Graphical integrity

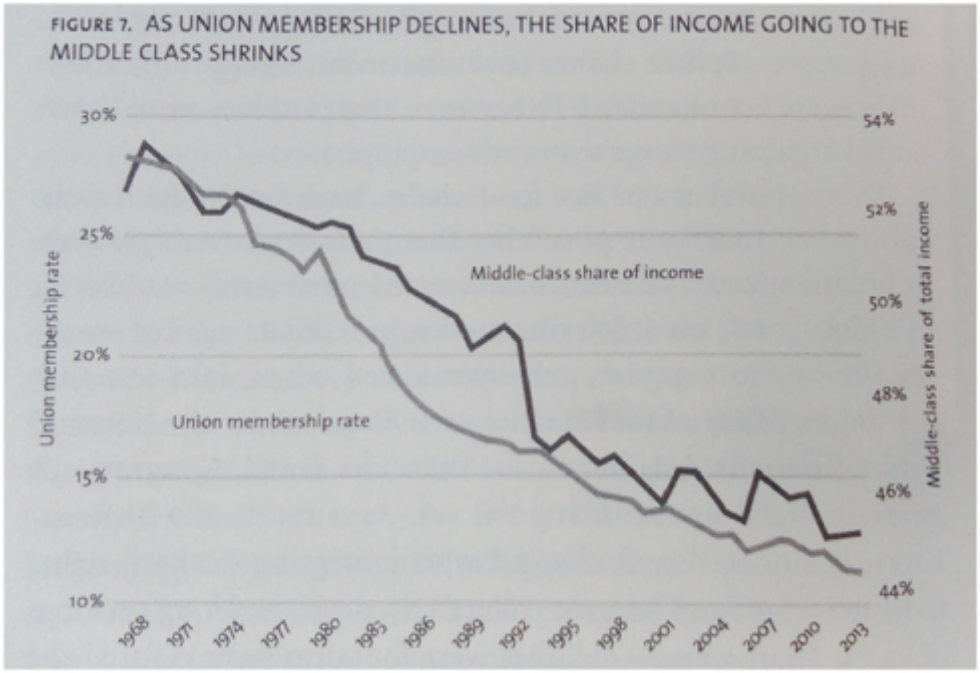



IF BUSH TAX CUTS EXPIRE
TOP TAX RATE
42%
40
38
36
34
39.6%
35%
NOW
JAN. 1, 2013
8:01p ET
FOX BUSINESS
TOP STORIES
TECHNOLOGY
CONSUMER
VITH THE JUSTICE DEPARTMENT AND AQUIRES FULL T
DOW 13008.68 64.33
S&P 1379.32 5.98
NASDAQ 2939.52 6.32

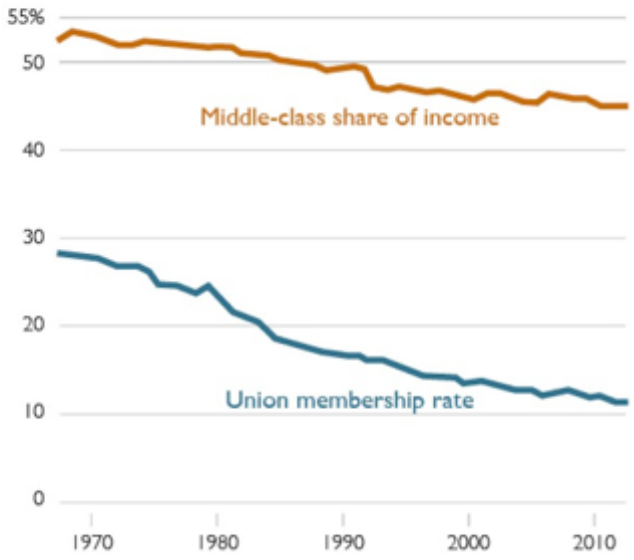
Graphical integrity

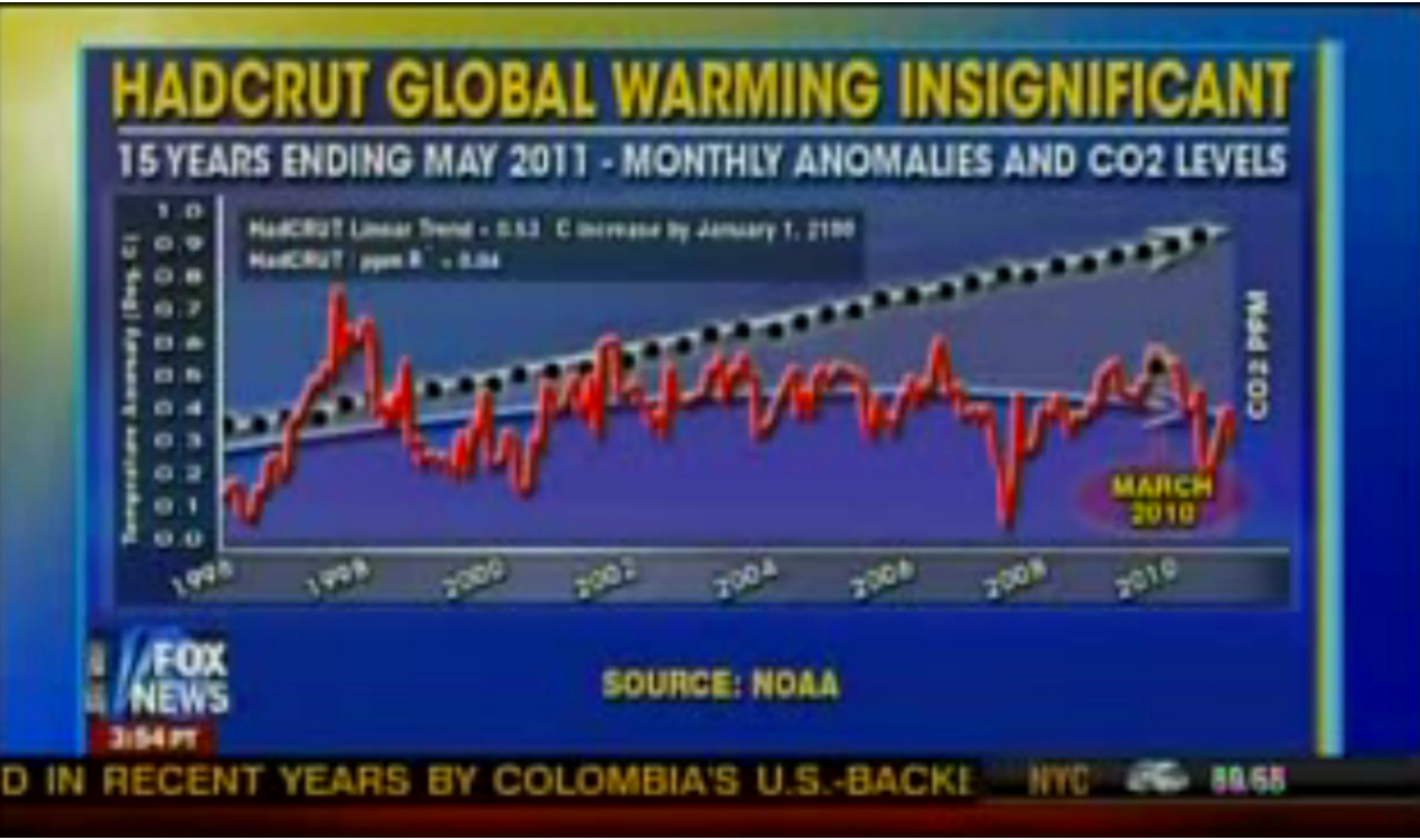


Scale distortions

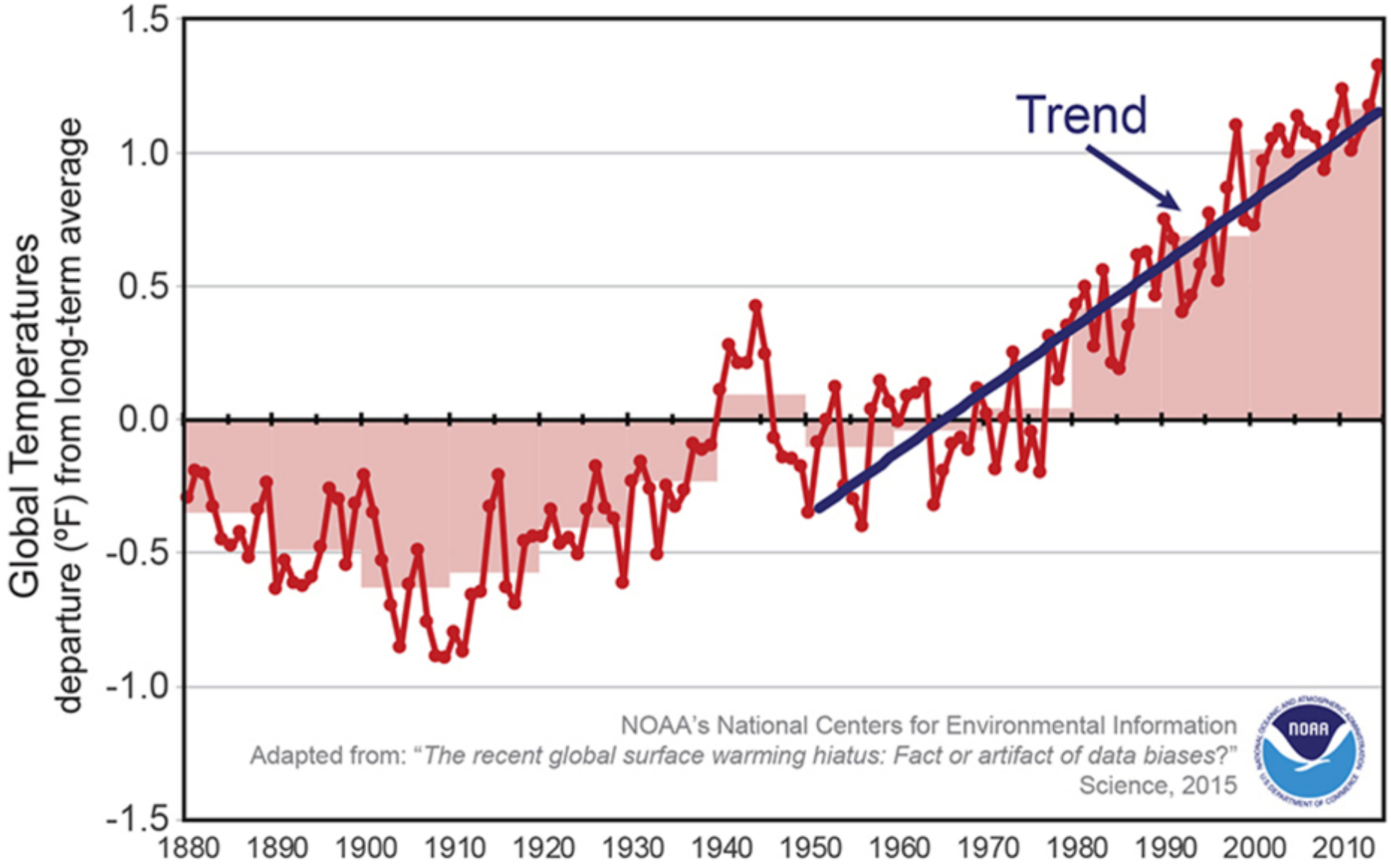


NEW VERSION



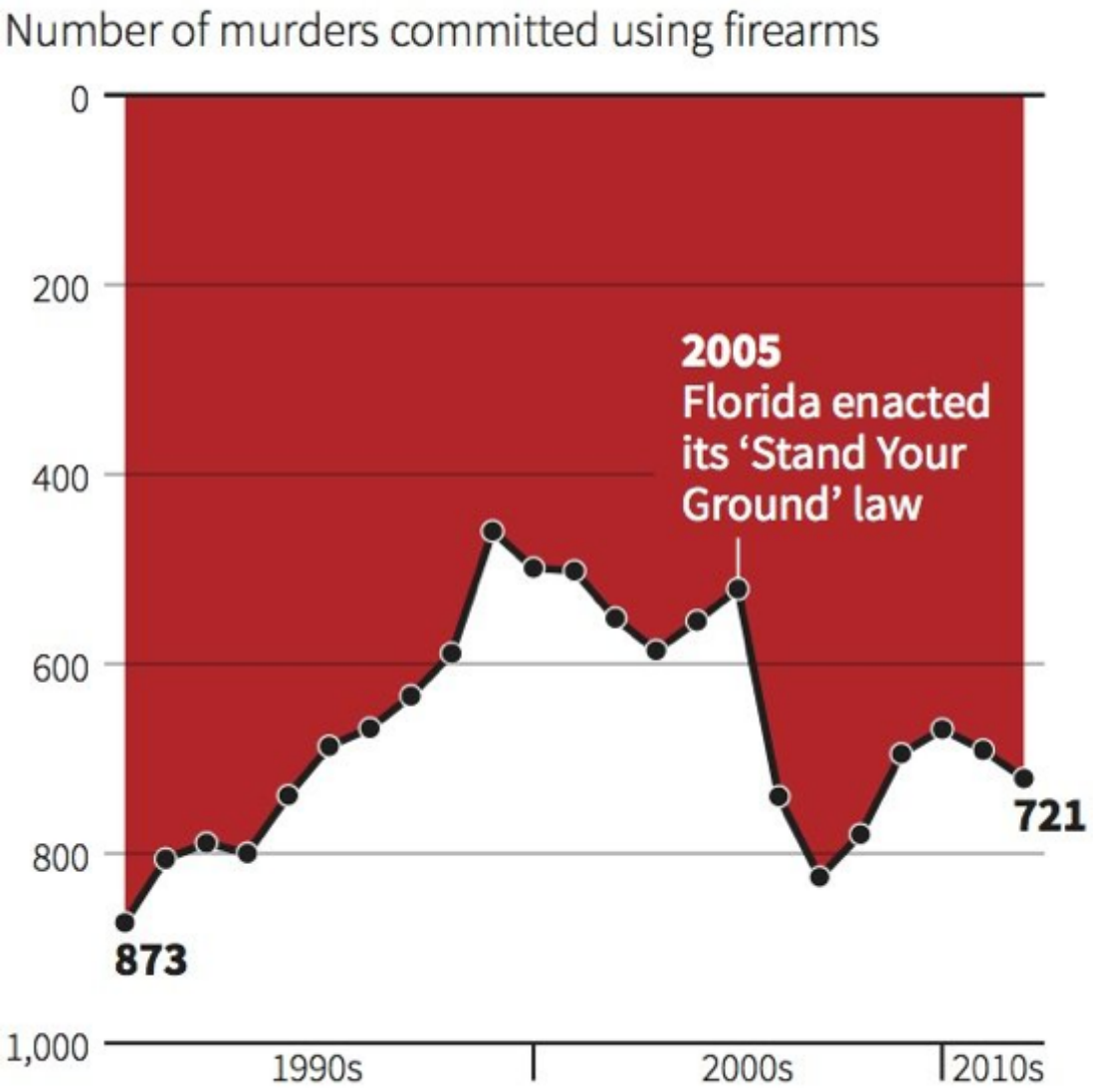

HADCRUT GLOBAL WARMING INSIGNIFICANT
15 YEARS ENDING MAY 2011 - MONTHLY ANOMALIES AND CO2 LEVELS
MARCH 2010
CO2 PPM
SOURCE: NOAA
FOX NEWS
D IN RECENT YEARS BY COLOMBIA'S U.S.-BACKI

No Slow Down in Global Warming



Contrary to much recent discussion, the latest corrected analysis shows that the rate of global warming has continued, and there has been no slow down.

Gun deaths in Florida



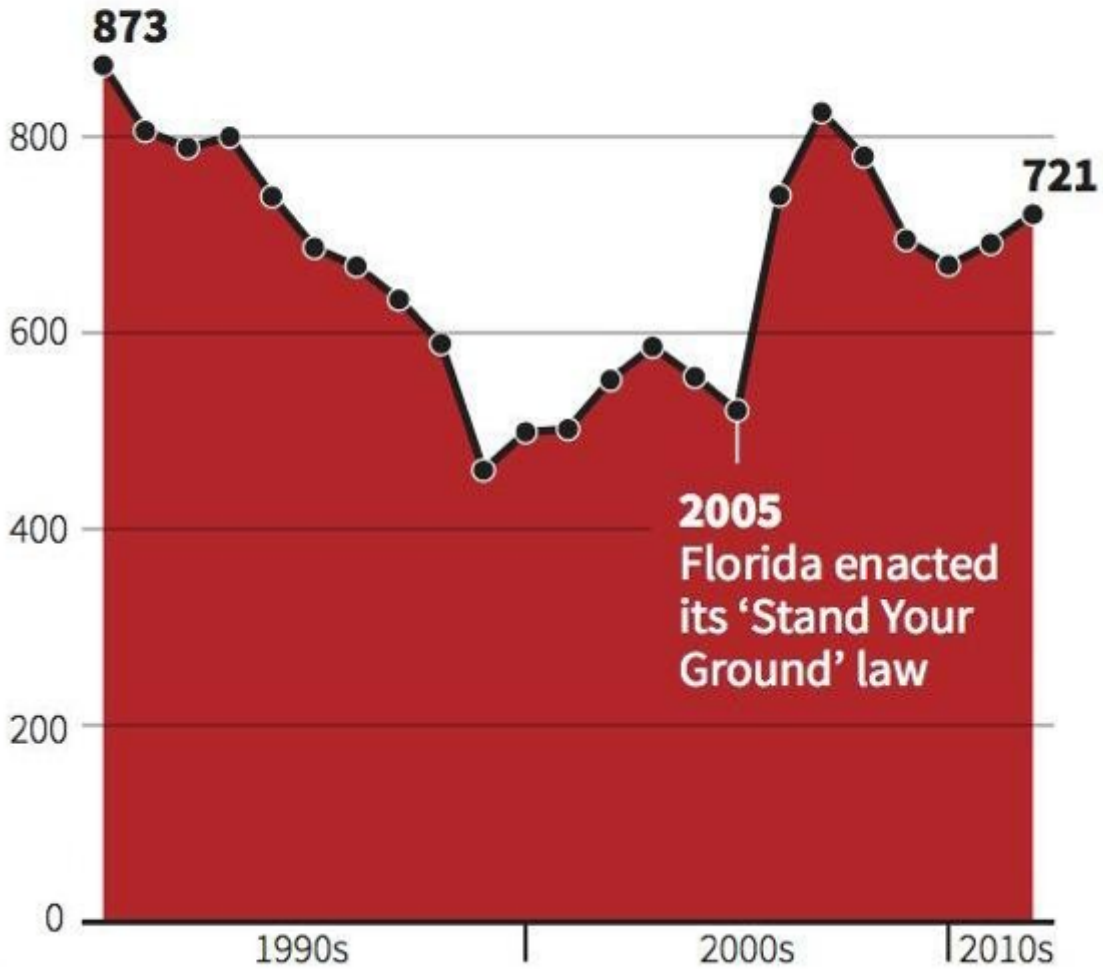
Source: Florida Department of Law Enforcement

C. Chan 16/02/2014

REUTERS

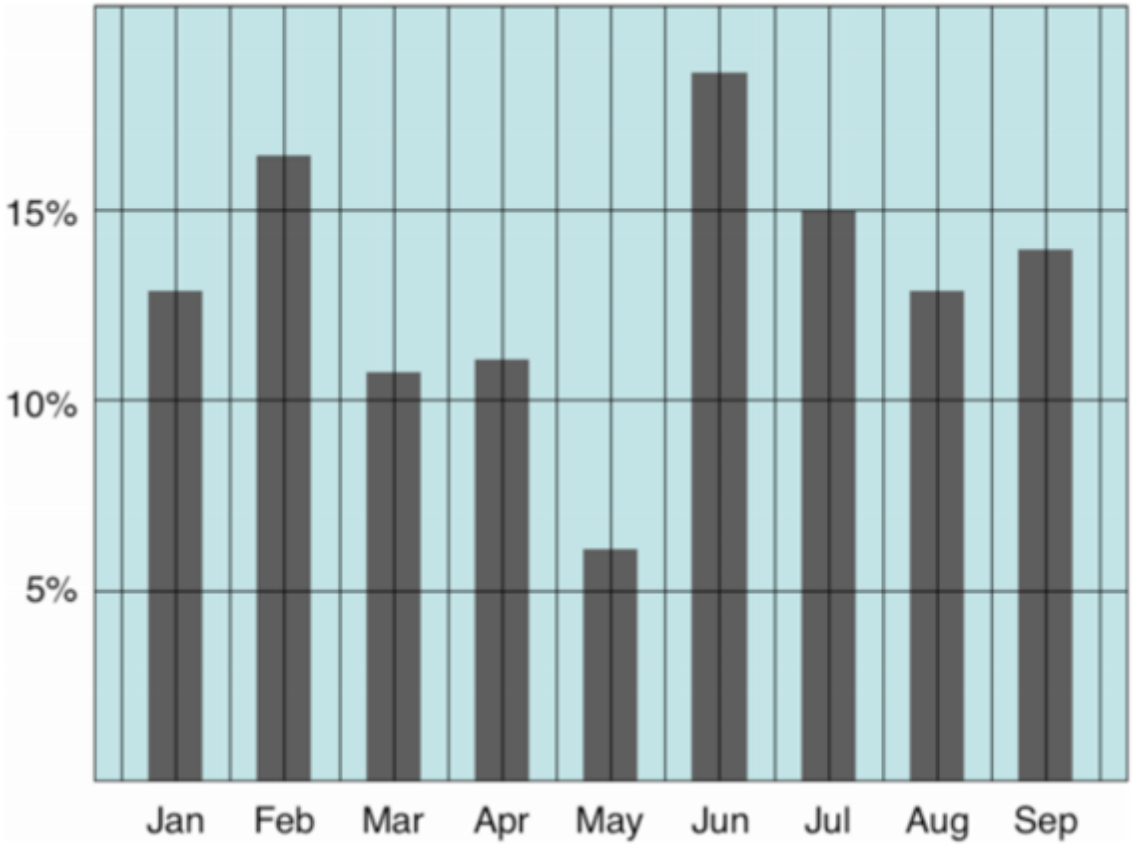
Gun deaths in Florida

Number of murders committed using firearms

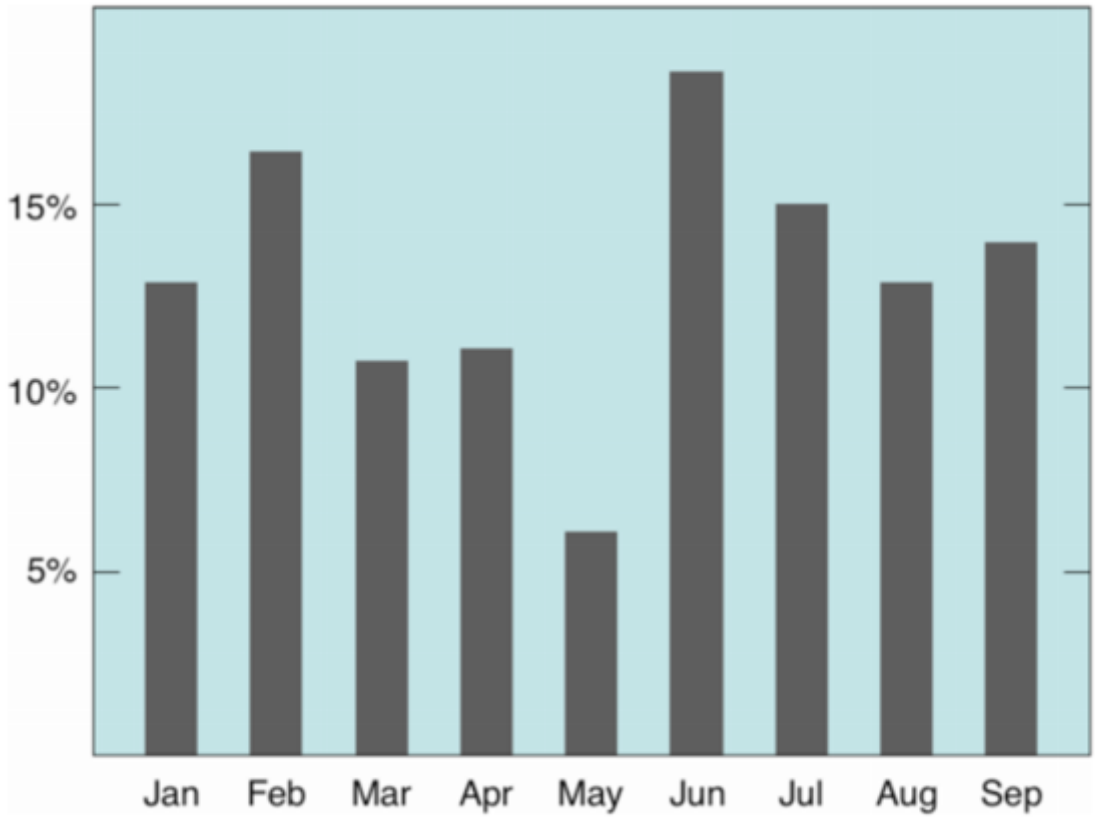


Source: Florida Department of Law Enforcement

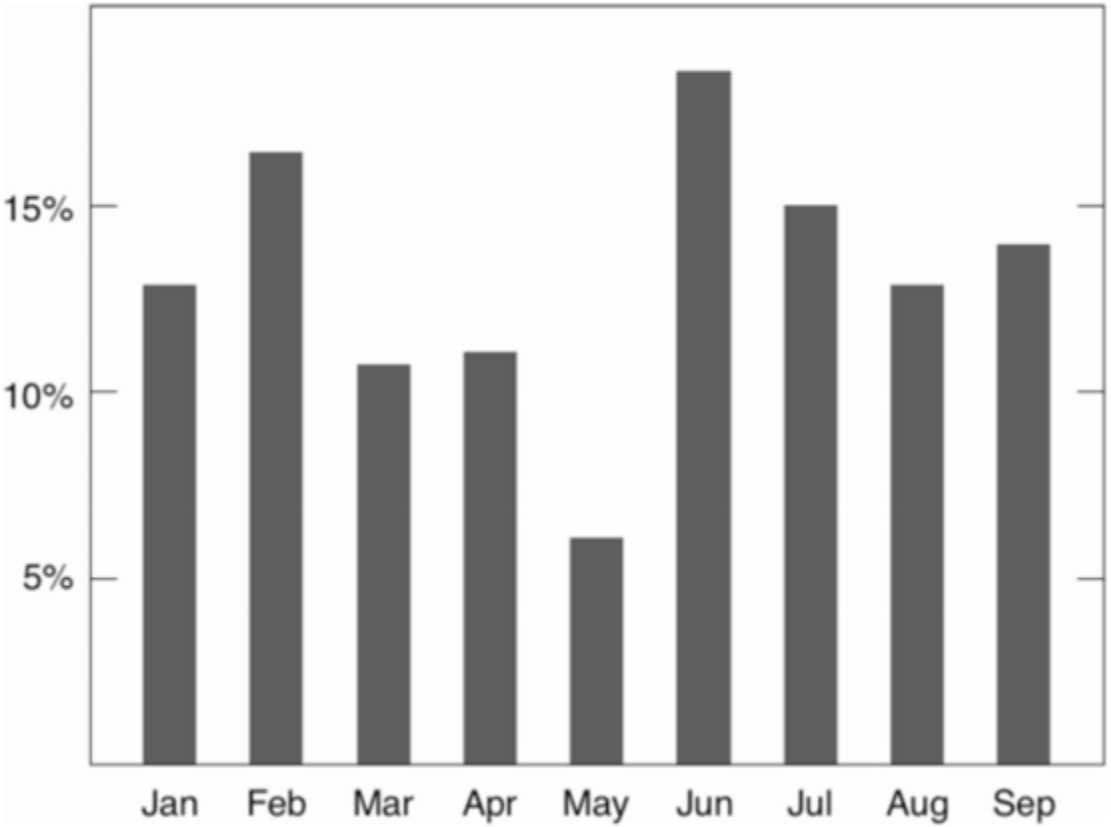
Avoid chartjunk



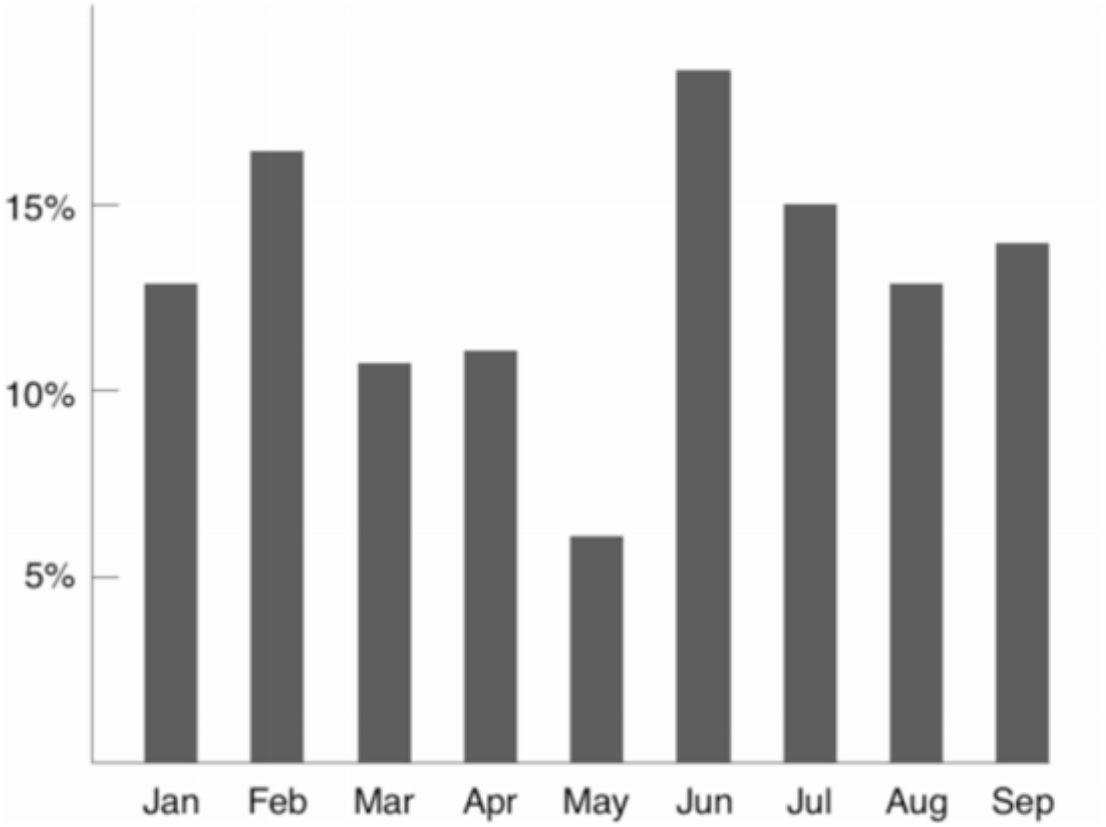
Avoid chartjunk



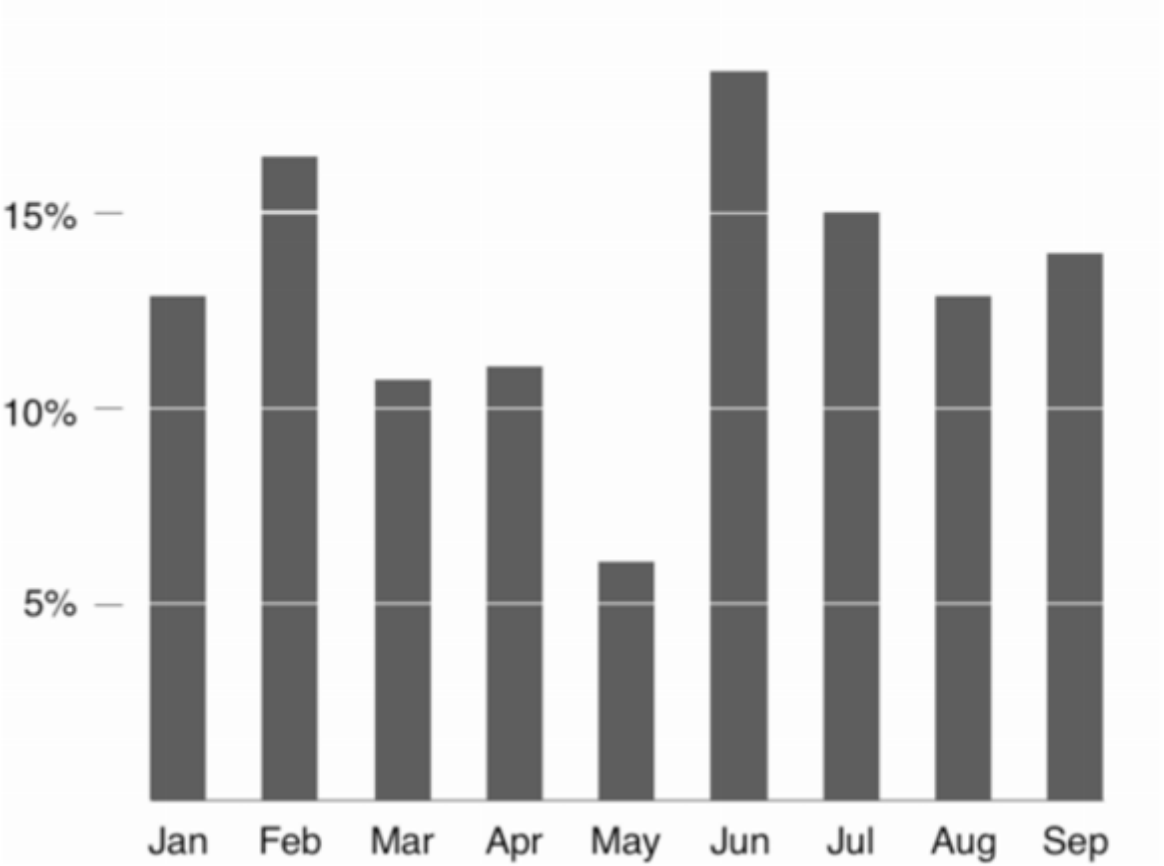
Avoid chartjunk



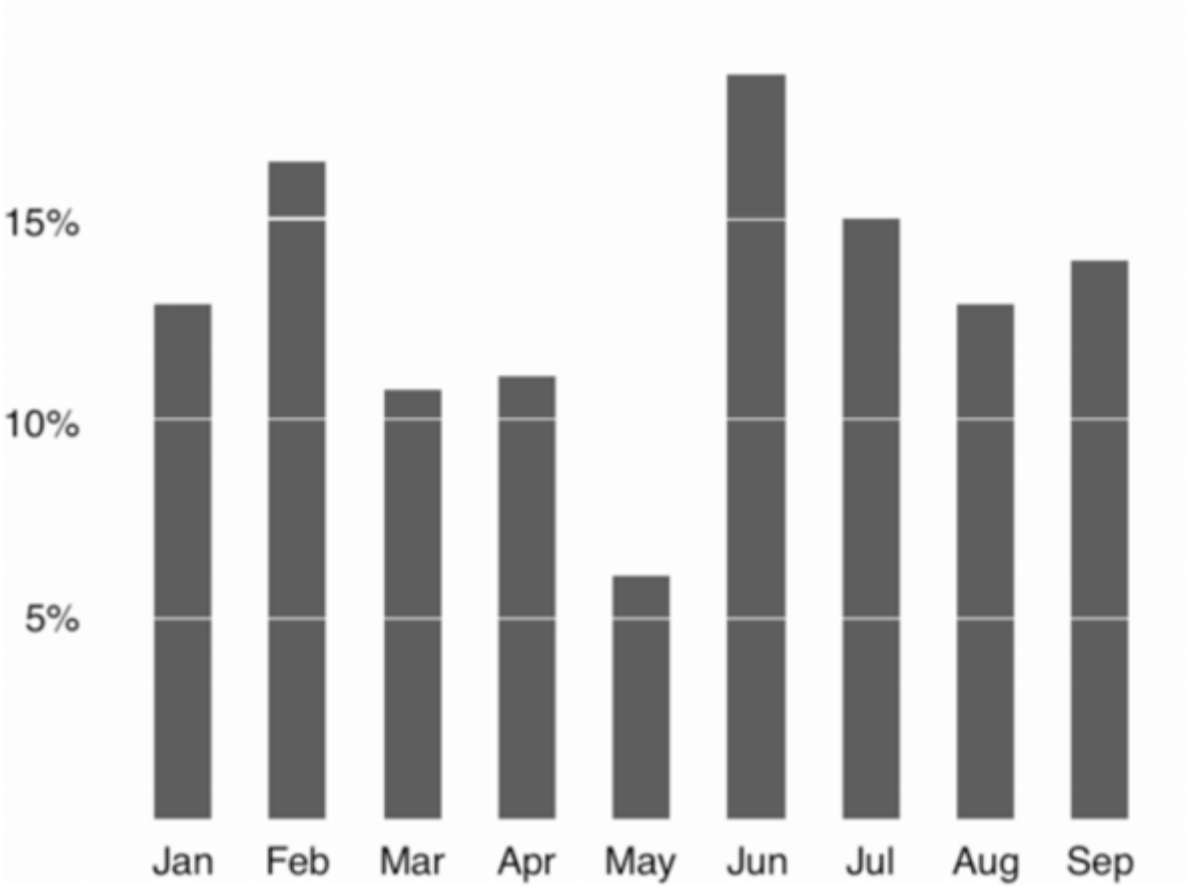
Avoid chartjunk



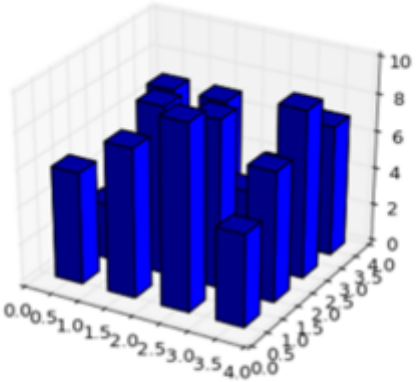
Avoid chartjunk

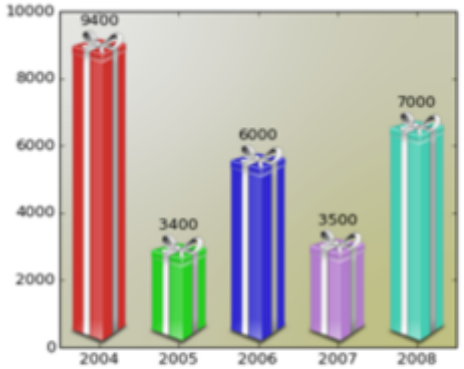


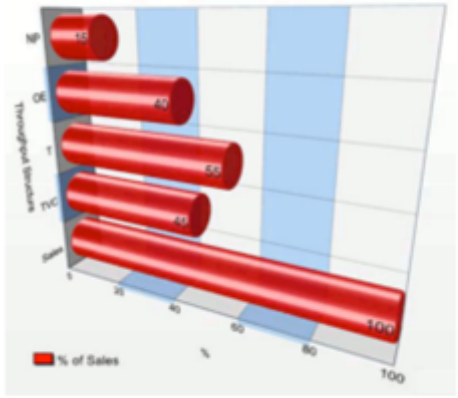
Avoid chartjunk



Examples of bad charts



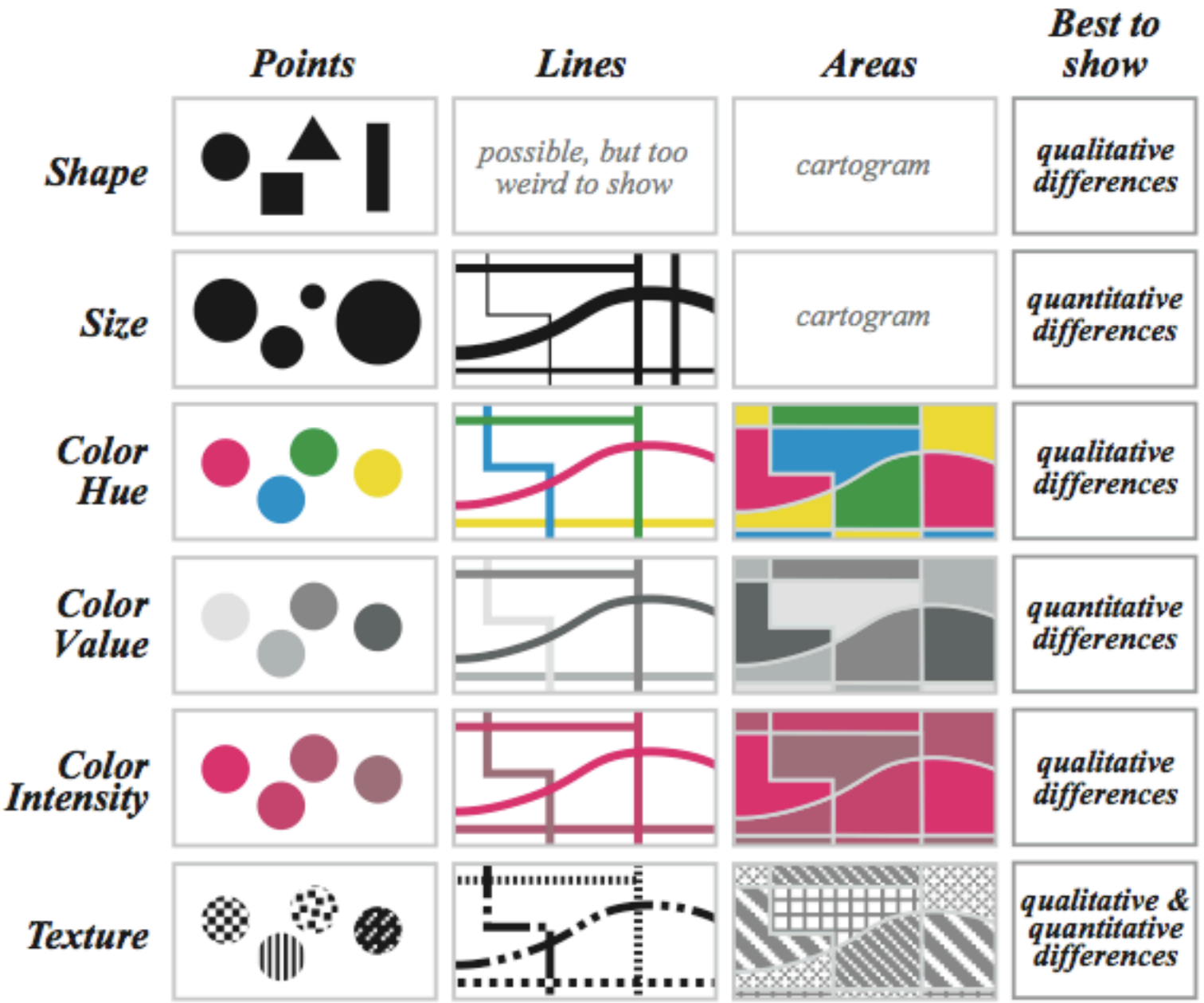


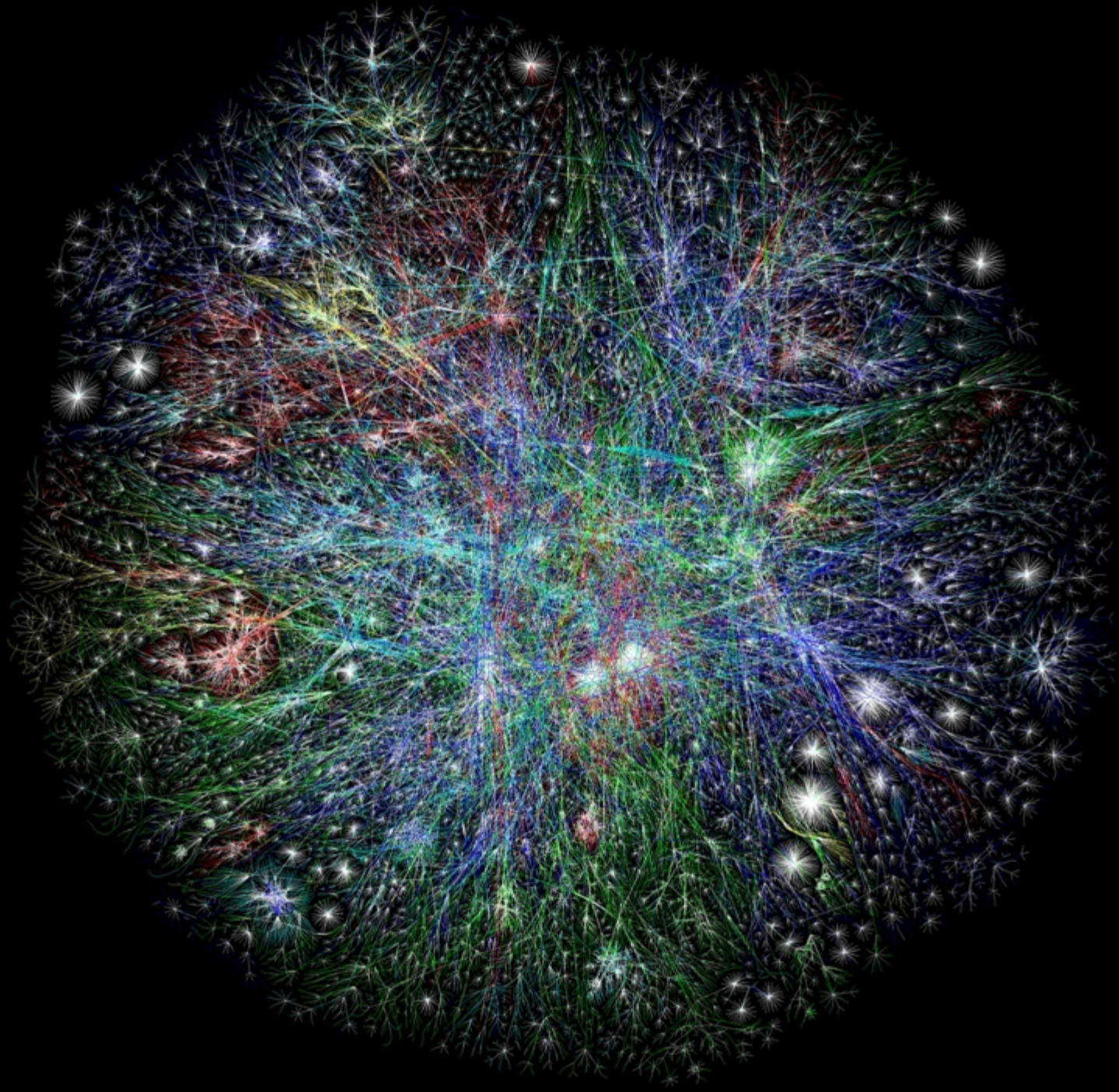


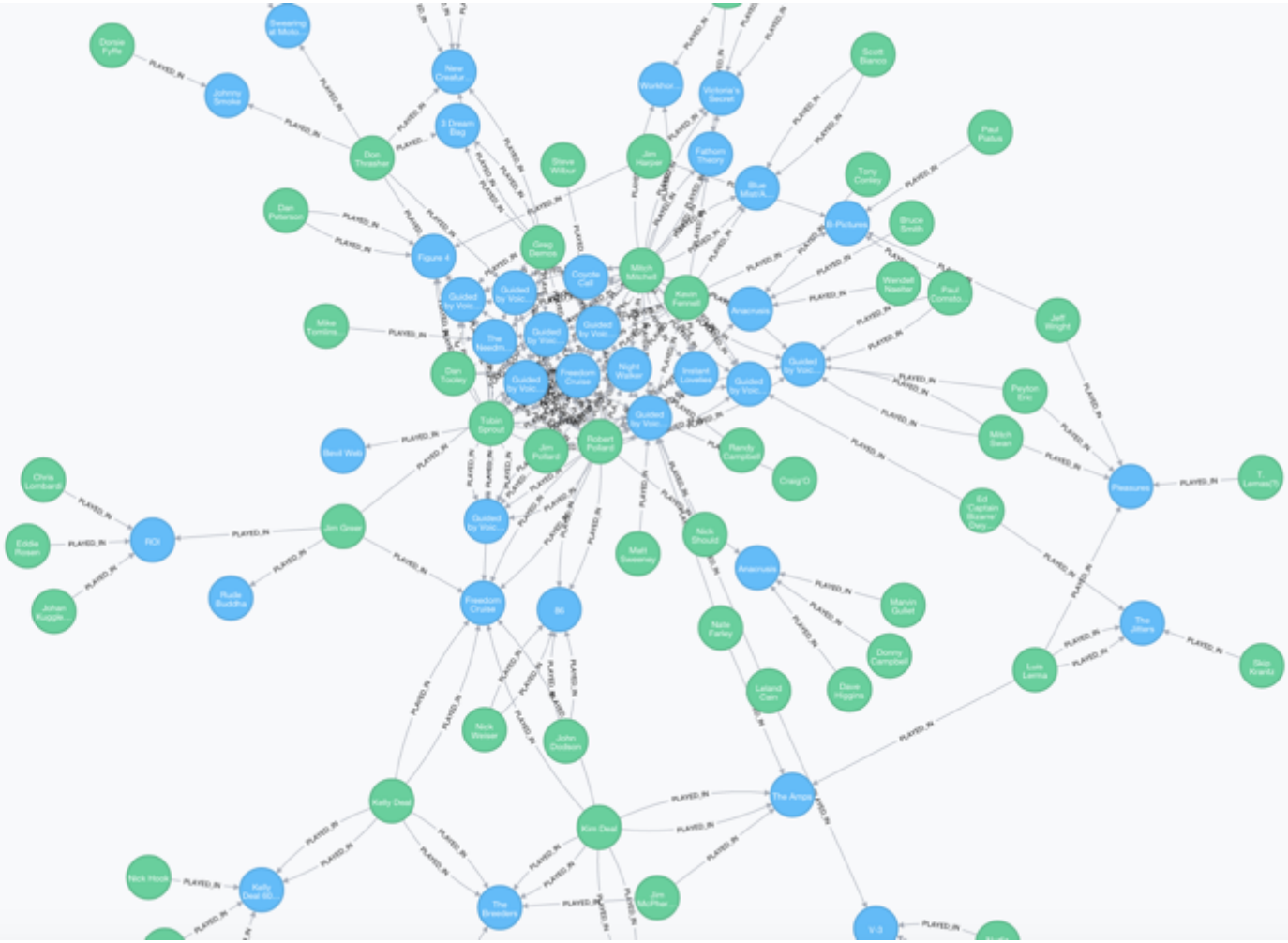
Visual Variables

- Basic model for stuff we measure (data):
  - From Science paper “On The Theory of Scales and Measurements”, basically:
    - Nominal scale – categorization
    - Ordinal scale – continuous, comparable
    - Interval scale – kind of like ordinal but no true zero
    - Ratios – can measure ratios and proportions
- Also, entities, relationships and attributes

=> Jacques Bertin’s Visual Variables


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

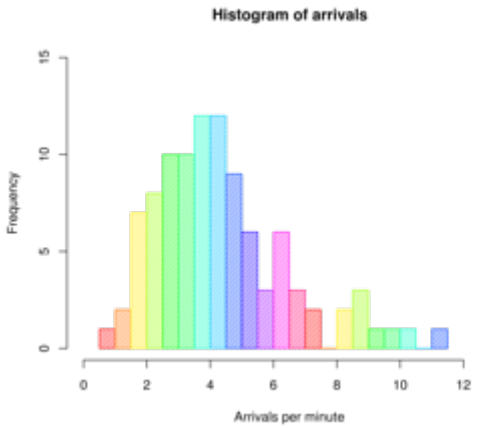


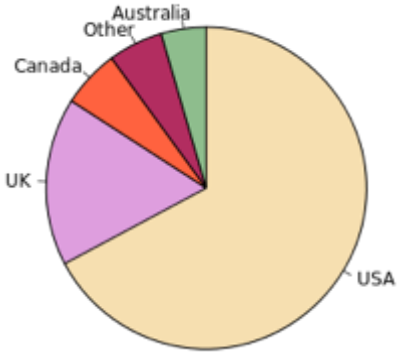


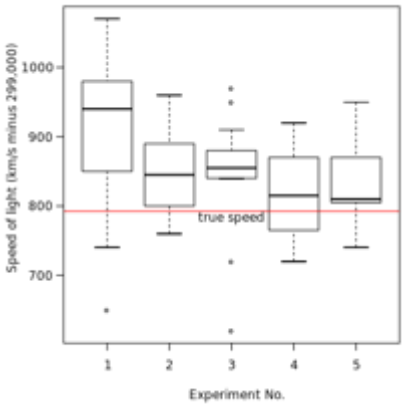
http://neo4j.com/graphgist/b9833a175976a959d7d6

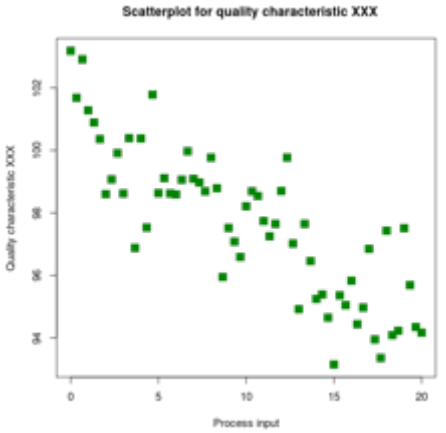
Charts

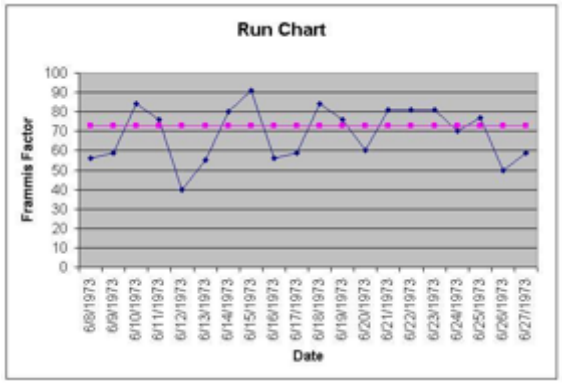
- Many many different kind of charts…











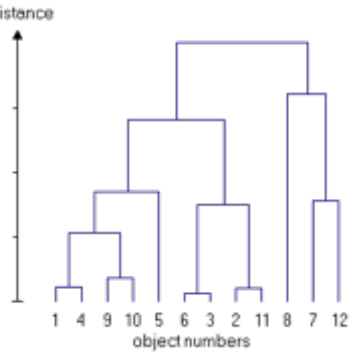
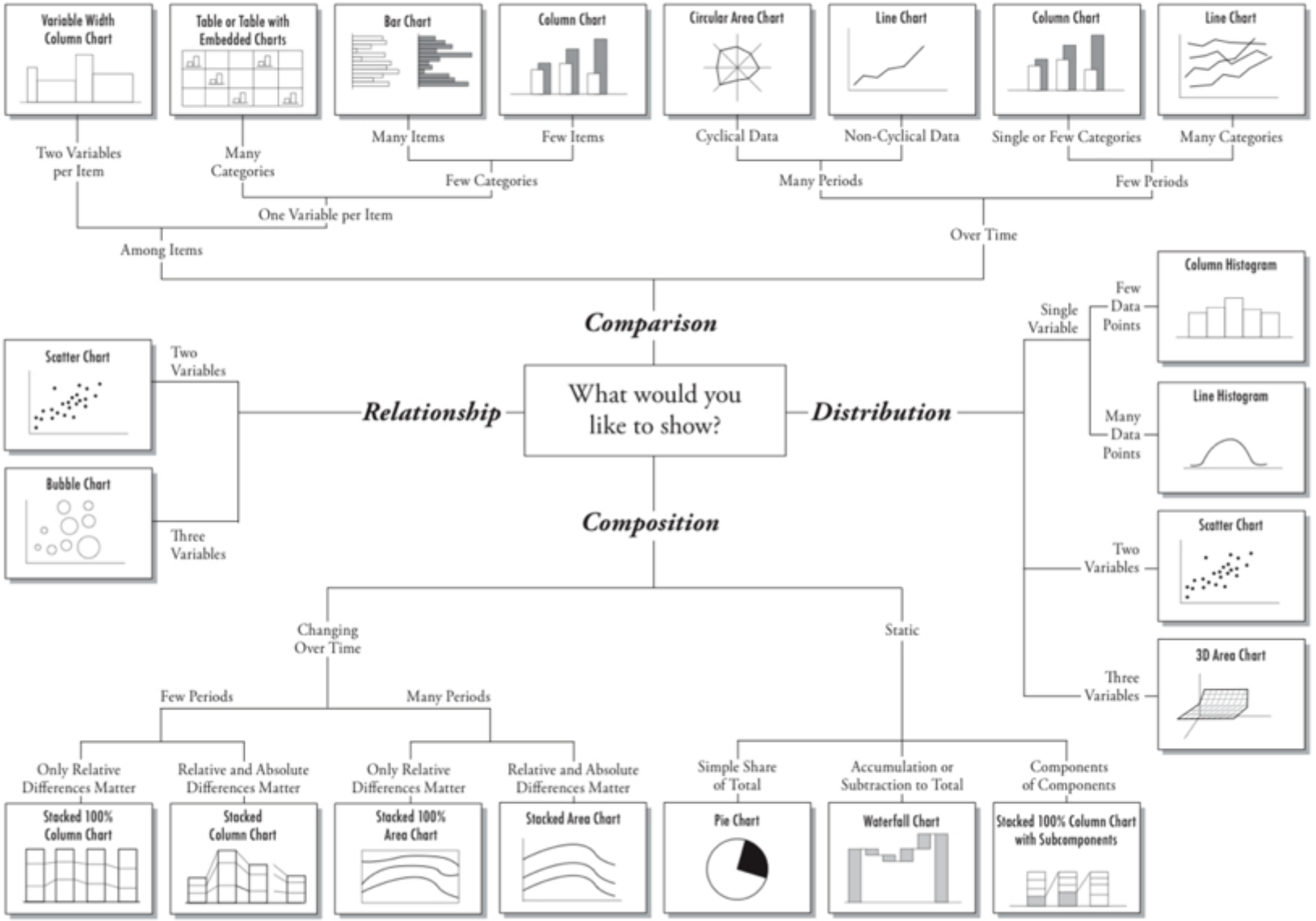
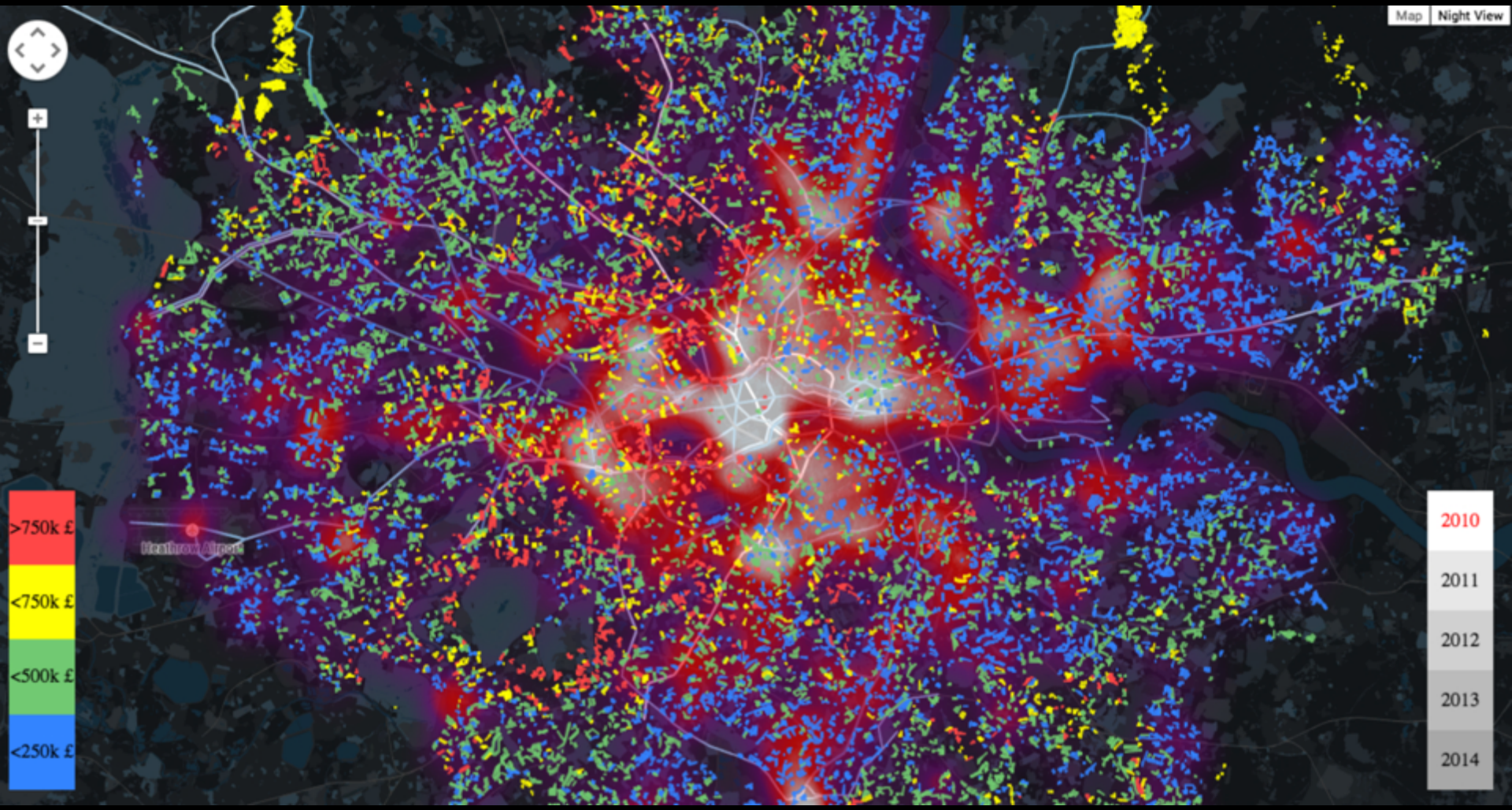


Chart Suggestions—A Thought-Starter

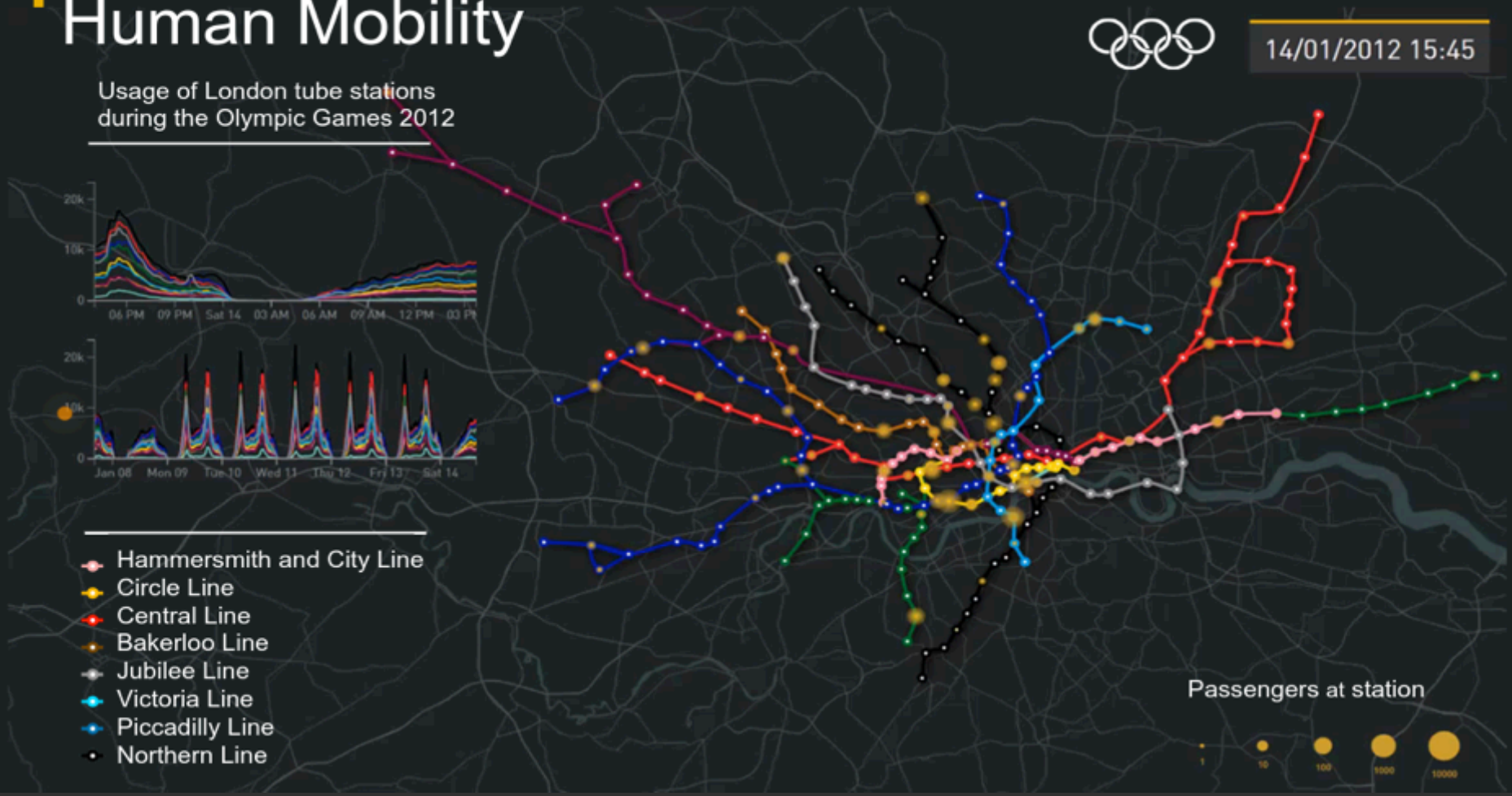


High dimensional data

- Heatmaps
- Connected charts
- Animations


Map
Night View
>750k £
<750k £
<500k £
<250k £
Heathrow Airport
2010
2011
2012
2013
2014

Energy & Environment of Future Cities: Human Mobility

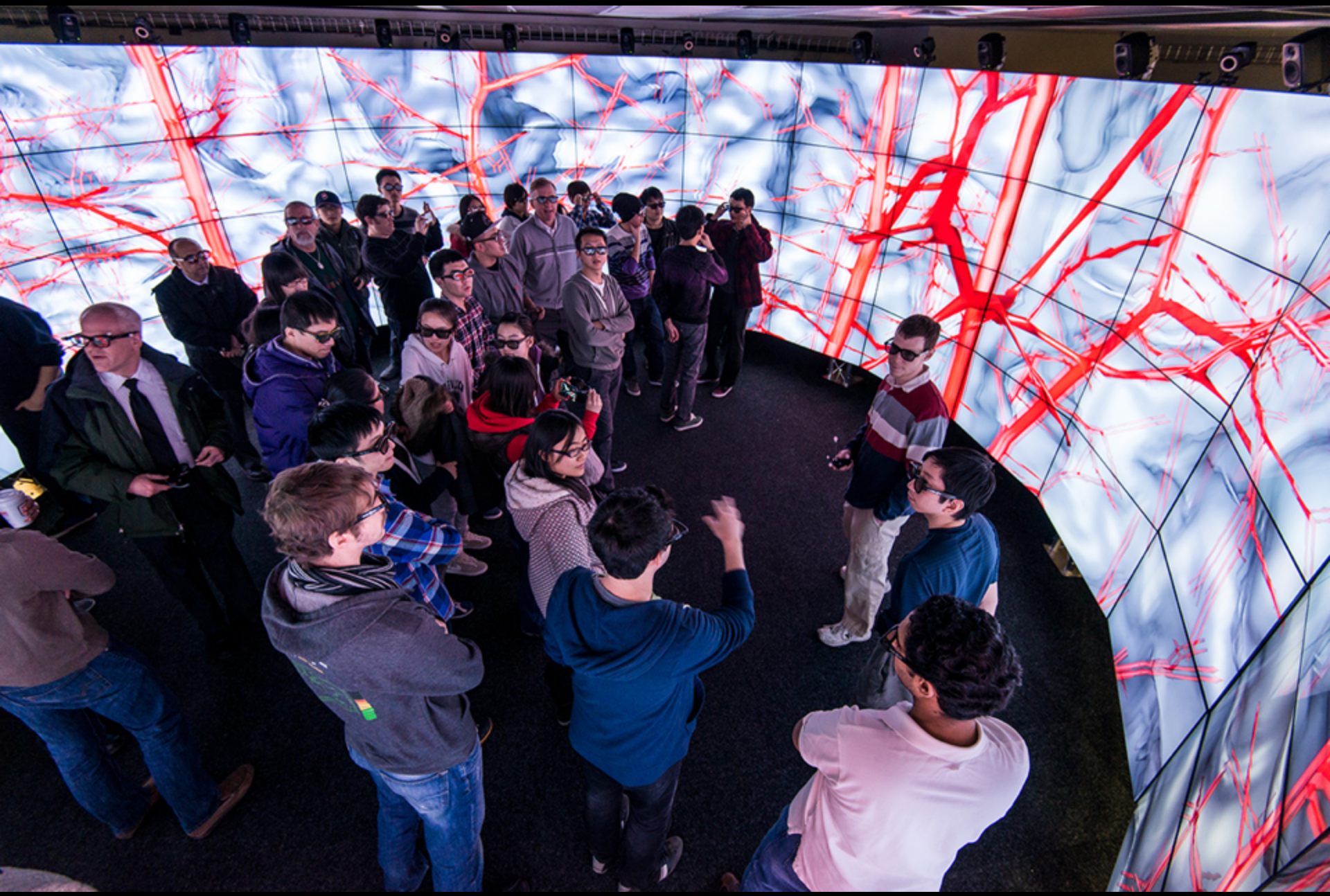


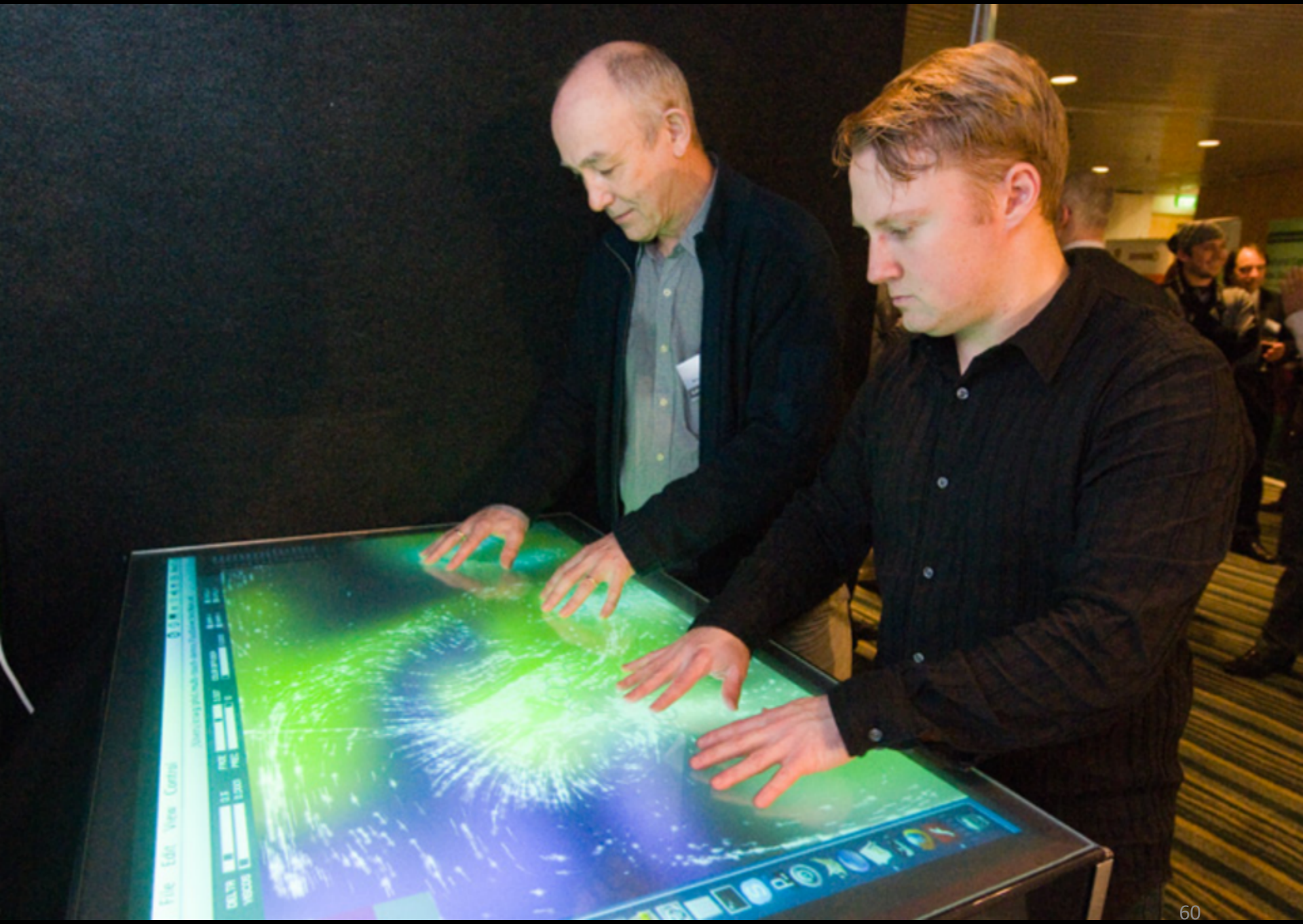
NYC version https://www.youtube.com/watch?v=g6EaMQDHu7Q

Visualization Systems

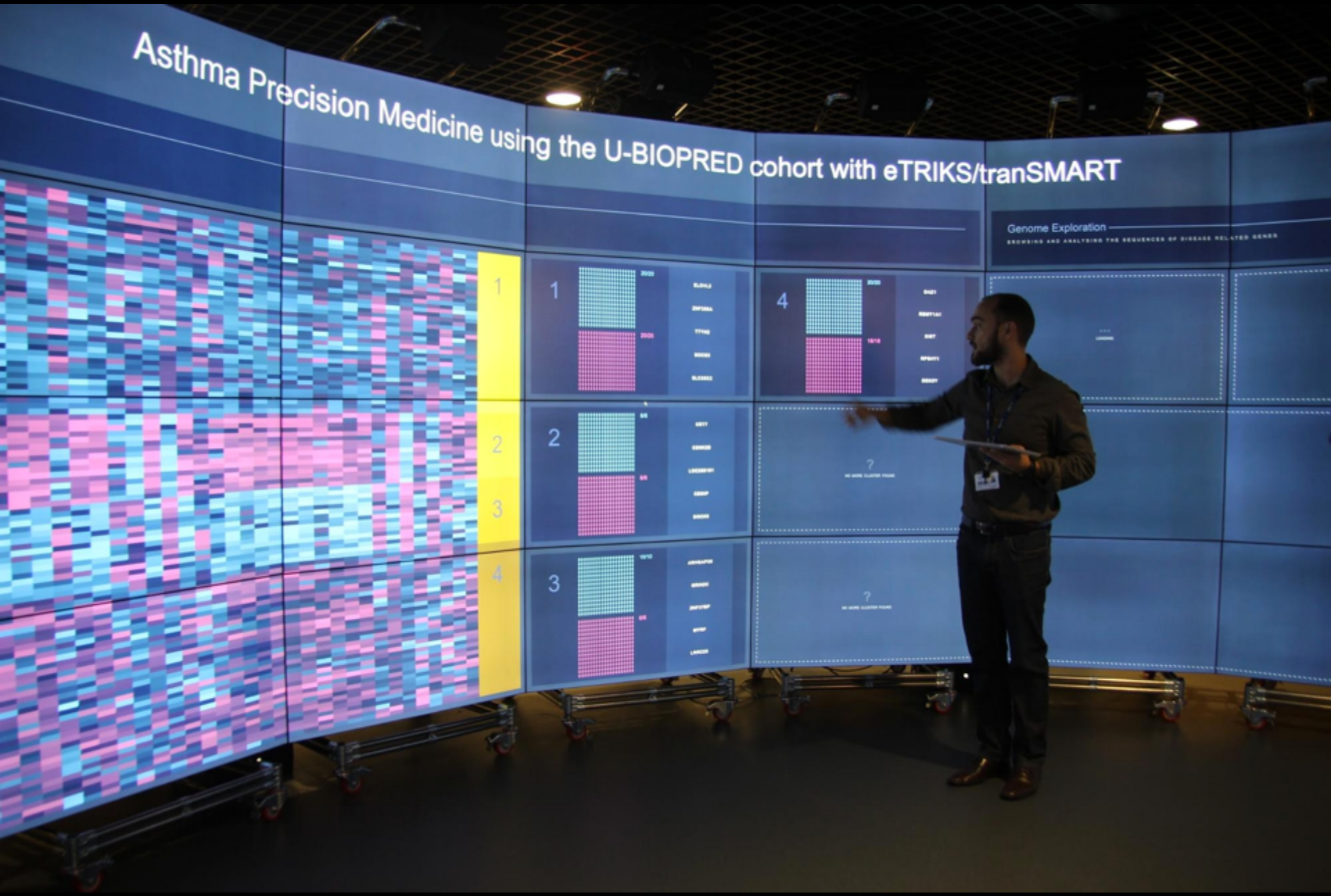
- Much visualization tooling is currently centered around how to present information on standard displays
  - Web
  - Desktop/laptop
  - Tablets/mobile

- What about on big devices/systems?






International Partners
国际合作单位
Imperial College London - Data Science Institute
Genomics England
Royal Brompton Hospital
European Translational Information and Knowledge Management Service
InnSMART Foundation
21:26
People Exiting Stations: 出站人数


Asthma Precision Medicine using the U-BIOPRED cohort with eTRIKS/tranSMART
Genome Exploration
1
2
3
4

How does this fit in with the rest of CLO?

- Visualization could plug into different stages of your processing pipeline in data science/experimental exercises.

- Important for how to turn your big data analyses into summarized and presentable artefacts (typically for human consumption)

- Externalizing data representation into visual artefacts to use our visual cognition compliments our mind's cognitive abilities to extract meaning from data.

Visualization tools and frameworks

- Code/scripting frameworks
  - D3 (JS, very very widely used), bokeh, matlibplot (Python), R, and loads loads more….
- Tools
  - Tableau, Circos, MATLAB, Octave and more…

…lab time!