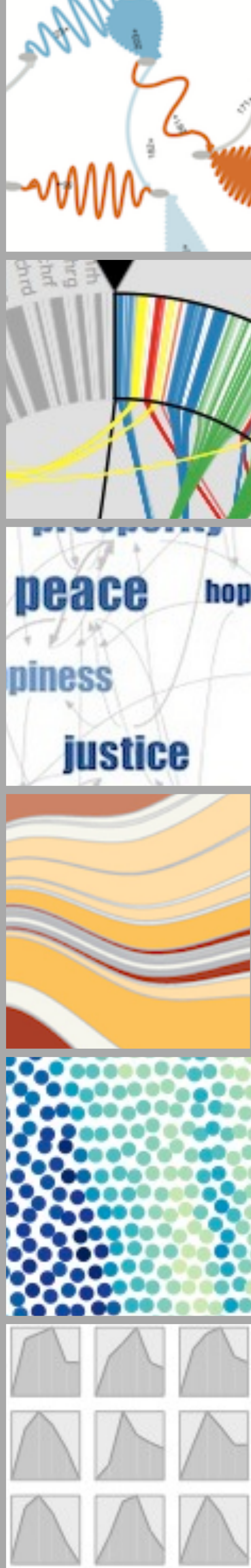
cs6964 | Jan 10 2012

INFORMATION VISUALIZATION

Miriah Meyer

University of Utah



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INFORMATION VISUALIZATION

Miriah Meyer
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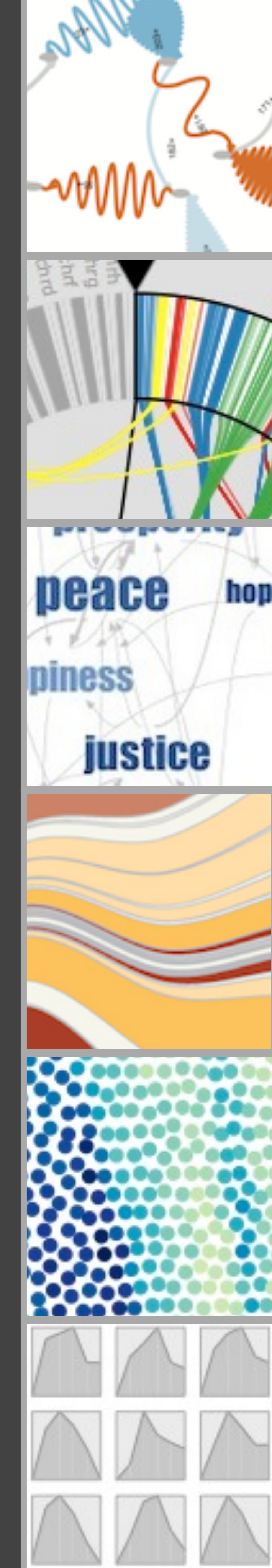
slide acknowledgements:
Hanspeter Pfister, Harvard University
Jeff Heer, Stanford University



- WHAT
- WHY
- WHO
- HOW

- WHAT
- WHY
- WHO
- HOW

INDUSTRIAL REVOLUTION OF DATA

Joe Hellerstein, UC Berkley, 2008

HOW MUCH DATA IS THERE?

2010: 1.2 zetabytes
2011: 1.8 zetabytes

zetabyte ~= 1,000,000,000,000,000,000,000,000 or 10^{24}

200x all words ever spoken by humans

9x increase over 5 years

[Gantz et al 2011] http://www.jamesshuggins.com/h/tek1/how_big.htm

The ability to take data—to be able to **understand** it, to **process** it, to **extract value** from it, to **visualize** it, to **communicate** it—that's going to be a hugely important skill in the next decades, ... because now we really do have essentially free and ubiquitous data. So the complimentary scarce factor is the ability to understand that data and extract value from it.

Hal Varian, Google's Chief Economist
The McKinsey Quarterly, Jan 2009

COGNITION IS LIMITED


The "Door" Study - YouTube
http://www.youtube.com/watch?v=FWSxSQsspiQ&list=UUoUA-CpKaFCCV2Uz__qNJZw&index=8&feature=plcp
Google
Apple Yahoo! Google Maps YouTube Wikipedia News (436) Popular Google Scholar
You Tube
Browse Movies Upload Create Account Sign In
The "Door" Study
profsimons Subscribe 10 videos
Copyright (c) 1998 Simons & Levin. All rights reserved.
0:20 / 1:37 360p
Like Add to Share
260,166
Uploaded by profsimons on Mar 13, 2010
This video shows footage from a 1998 study by Daniel Simons and Daniel Levin in which a participant fails to notice when the person he is talking to is replaced by someone else. The study was among the first to demonstrate that the phenomenon of "change blindness" can occur outside the laboratory.
249 likes, 5 dislikes
As Seen On:
DefensiveCarry Concea...
Show more
Top Comments
This explains a lot about one of my ex-boyfriends. "If it looks like a girl, and it feels like a girl, and it smells like a girl, and it acts like a girl... it must be my girlfriend."
ataaah 1 year ago 141
Change Blindness 1
by yeblind
36,759 views
Featured Video
Gradual Change Test 1
by profsimons
34,443 views
Change Blindness
by trutapes
25,498 views
Test Your Awareness.....
by beepsquick
43,847 views
Perception of beauty
by andreic27
92,589 views
Amazing Fire & Gas Trick!
by brusspup
1,078,932 views
Try To Watch This Without Laughing Or
by 88ownsnascar
2,042,315 views
How much is:
75 + 26
Sociopath Test
by Daanando
213,997 views
Awareness Test
by J0EKthePANDA

MTHIVLWYADCEQGHKILKMTWYN
ARDCAIREQGHLVKMFPSTWYARN
GFPSVCEILQGKMFPSNDRCEQDIFP
SGHLMFHKMVPSTWYACEQTWRN

MTHI**V**LWYADCEQGHKILKMTWYN
ARDCAIREQGHL**V**KMFPSTWYARN
GFPS**V**CEILQGKMFPSNDRCEQDIFP
SGHLMFHKM**V**PSTWYACEQTWRN

VISUALIZATION . . .

1) uses perception to free up cognition

MEMORY IS LIMITED

calculation exercise . . .

$$\begin{array}{r} 34 \\ \times\ 28 \\ \hline \end{array}$$

calculation exercise …

$$\begin{array}{r} 79 \\ \times\ 16 \\ \hline \end{array}$$

VISUALIZATION . . .

1) uses perception to free up cognition

2) serves as an external aid to augment working memory

vi·su·al·i·za·tion

noun, plural -s

1) formation of mental visual images

2) the act or process of interpreting in visual terms or of putting into visible form

"The use of computer-generated, interactive, visual representations of data to amplify cognition."

[Card, Mackinlay, & Shneiderman 1999]

- WHAT
- WHY
- WHO
- HOW

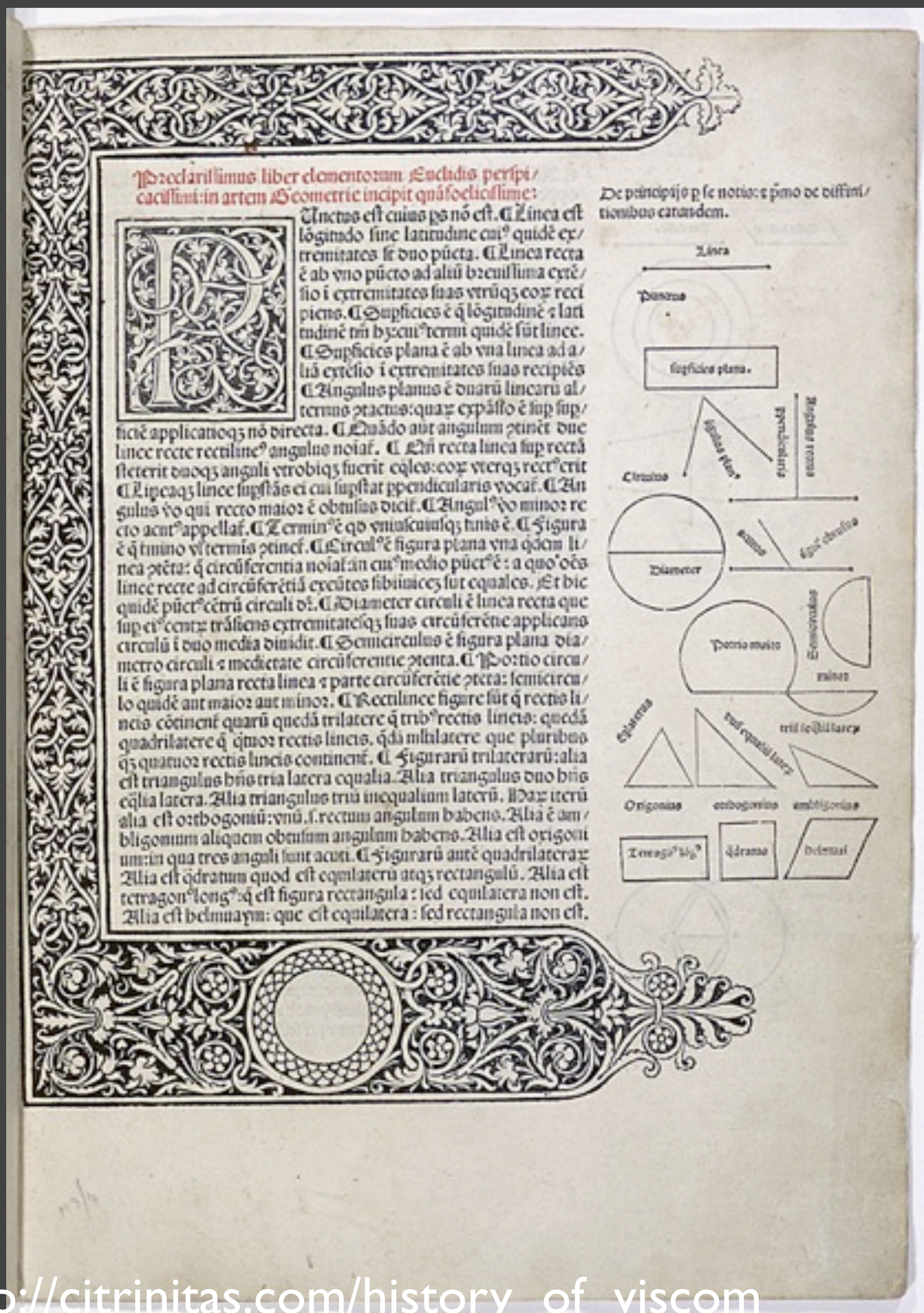
“It is things that make us smart”

Donald Norman

http://citrinitas.com/history_of_viscom

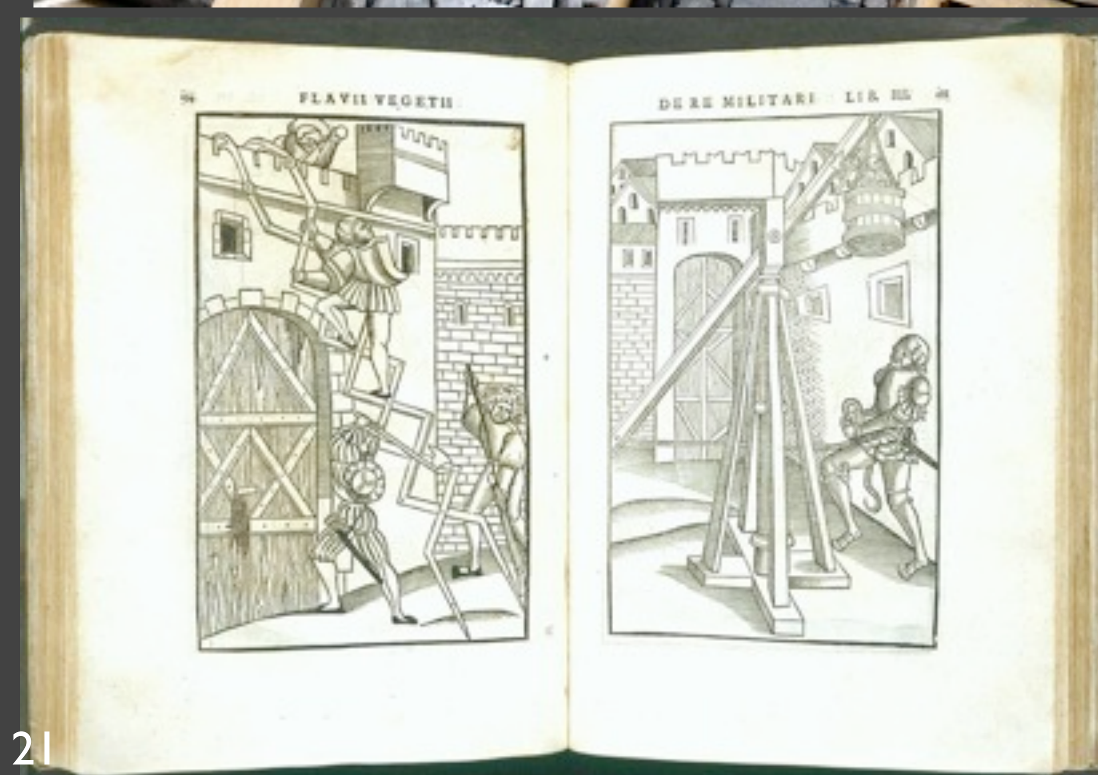
“It is things that make us smart”

Donald Norman



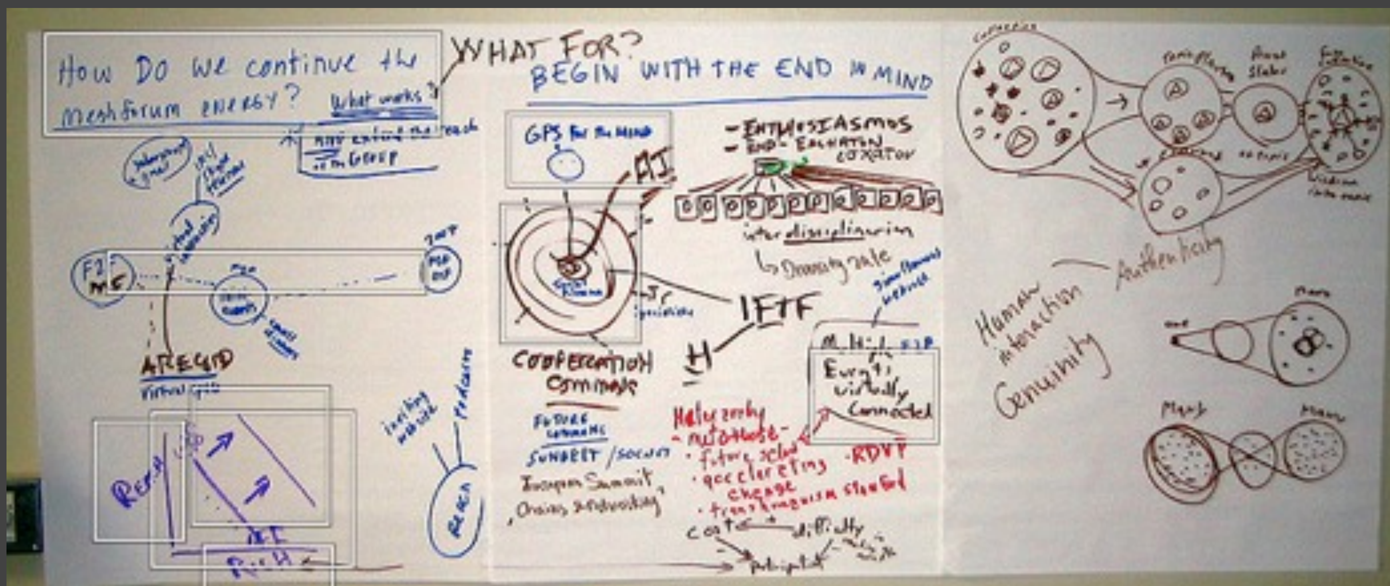
Preclarissimus liber elementorum Euclidis perspicacissimi: in artem Geometrie incipit quam foelicissime:

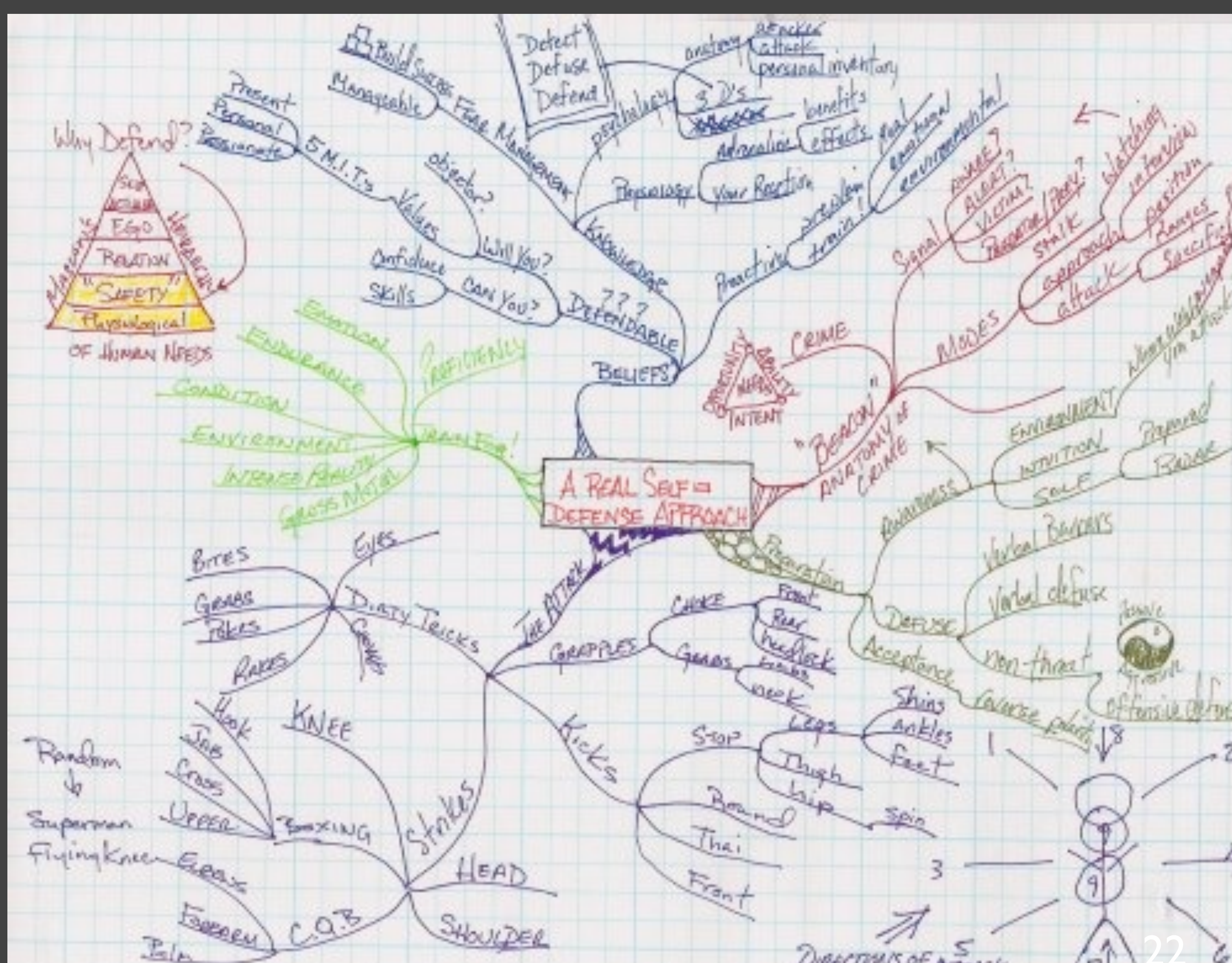
De principiis p se notis: e primo de diffinitionibus earundem.



"It is things that make us smart"

Donald Norman





Visual Thinking Collection, Dave Grey

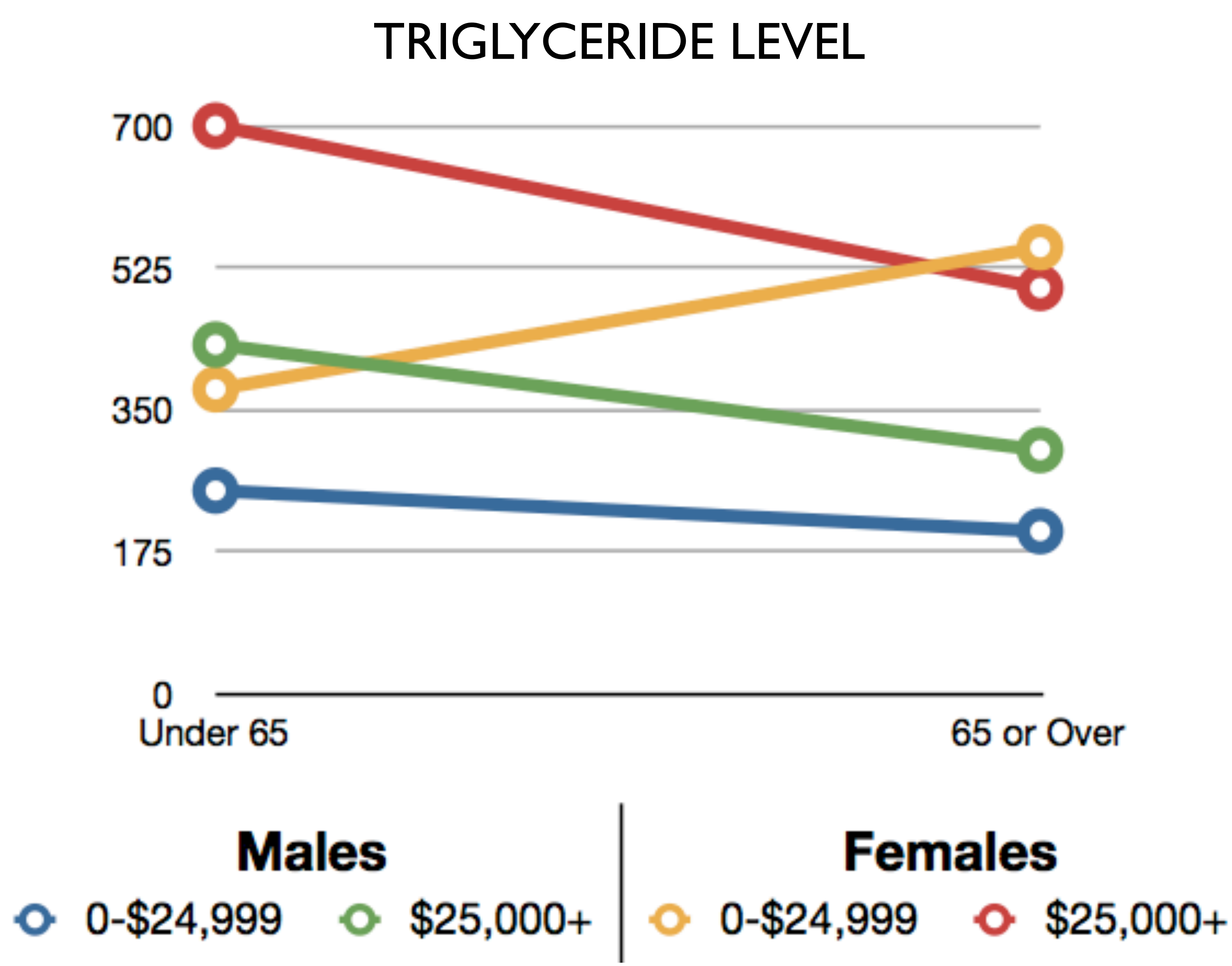
query exercise . . .

TRIGLYCERIDE LEVEL

	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

QUESTION:

Which gender and income level shows a different effect of age on triglyceride levels?



QUESTION:

Which gender and income level shows a different effect of age on triglyceride levels?

Why do we create visualizations?

- answer questions
- generate hypotheses
- make decisions
- see data in context
- expand memory
- support computational analysis
- find patterns
- tell a story
- inspire

VISUALIZATION GOALS

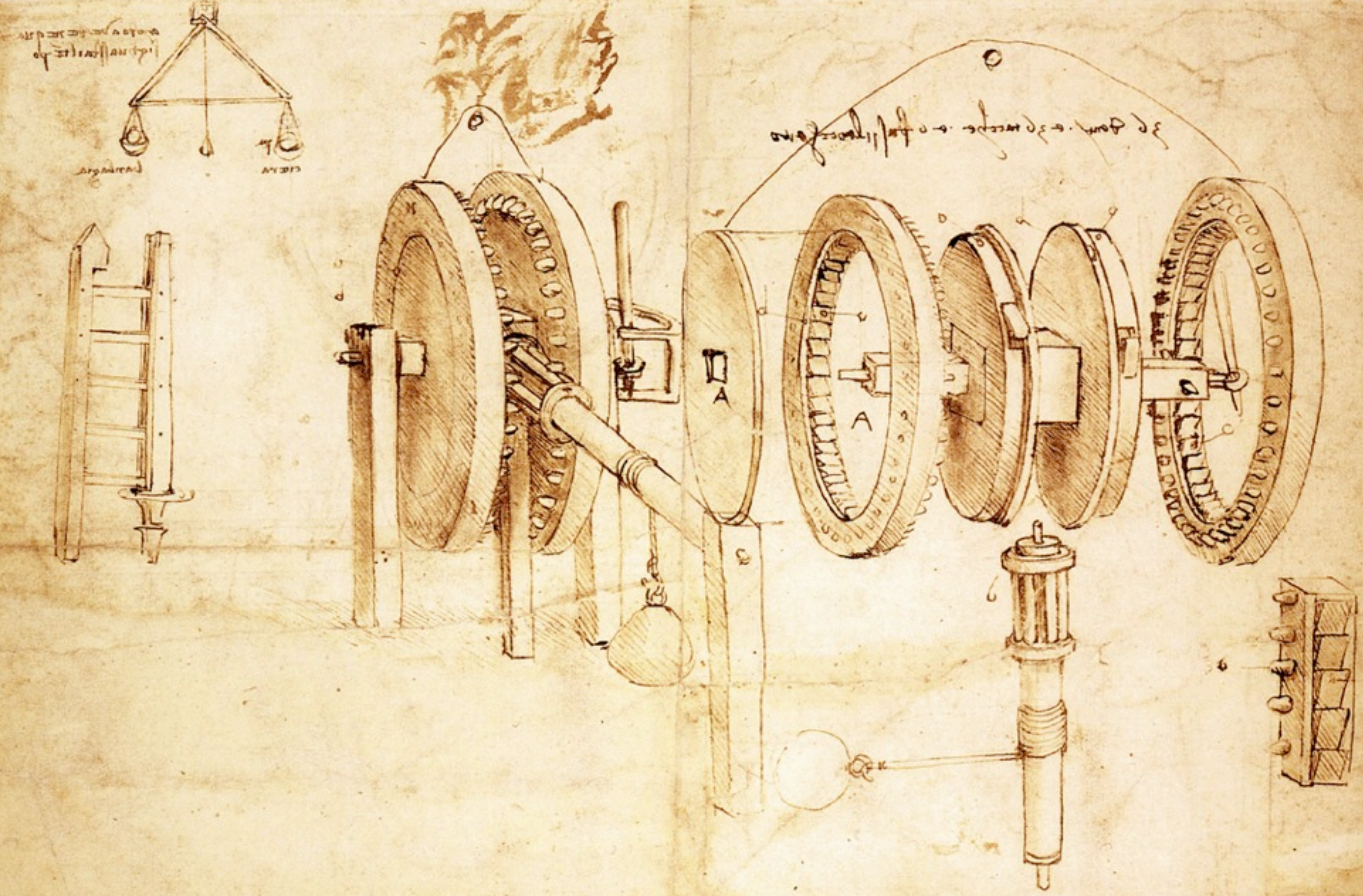
-**record** information

-**analyze** data to support reasoning

-**confirm** hypotheses

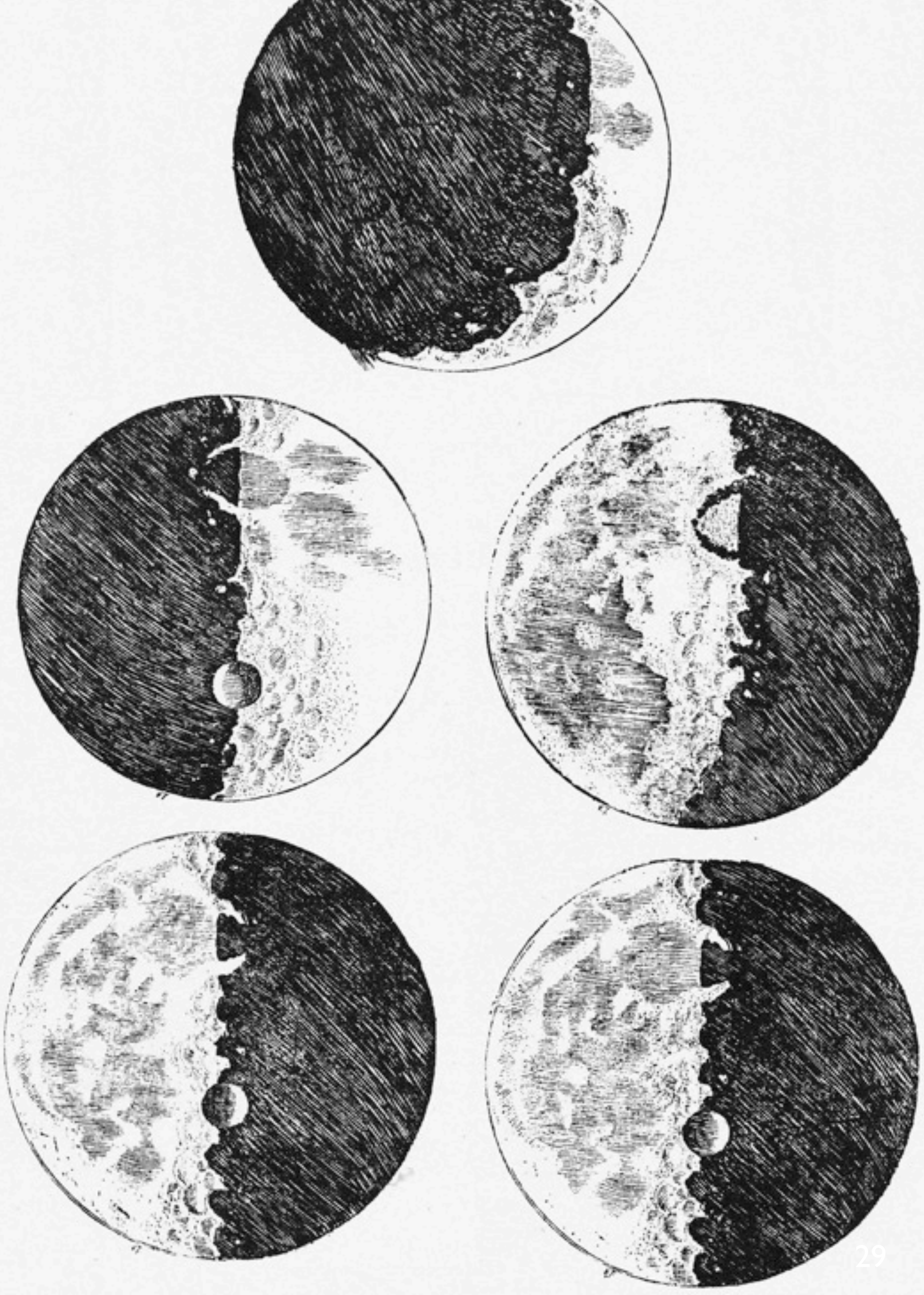
-**communicate** ideas to others

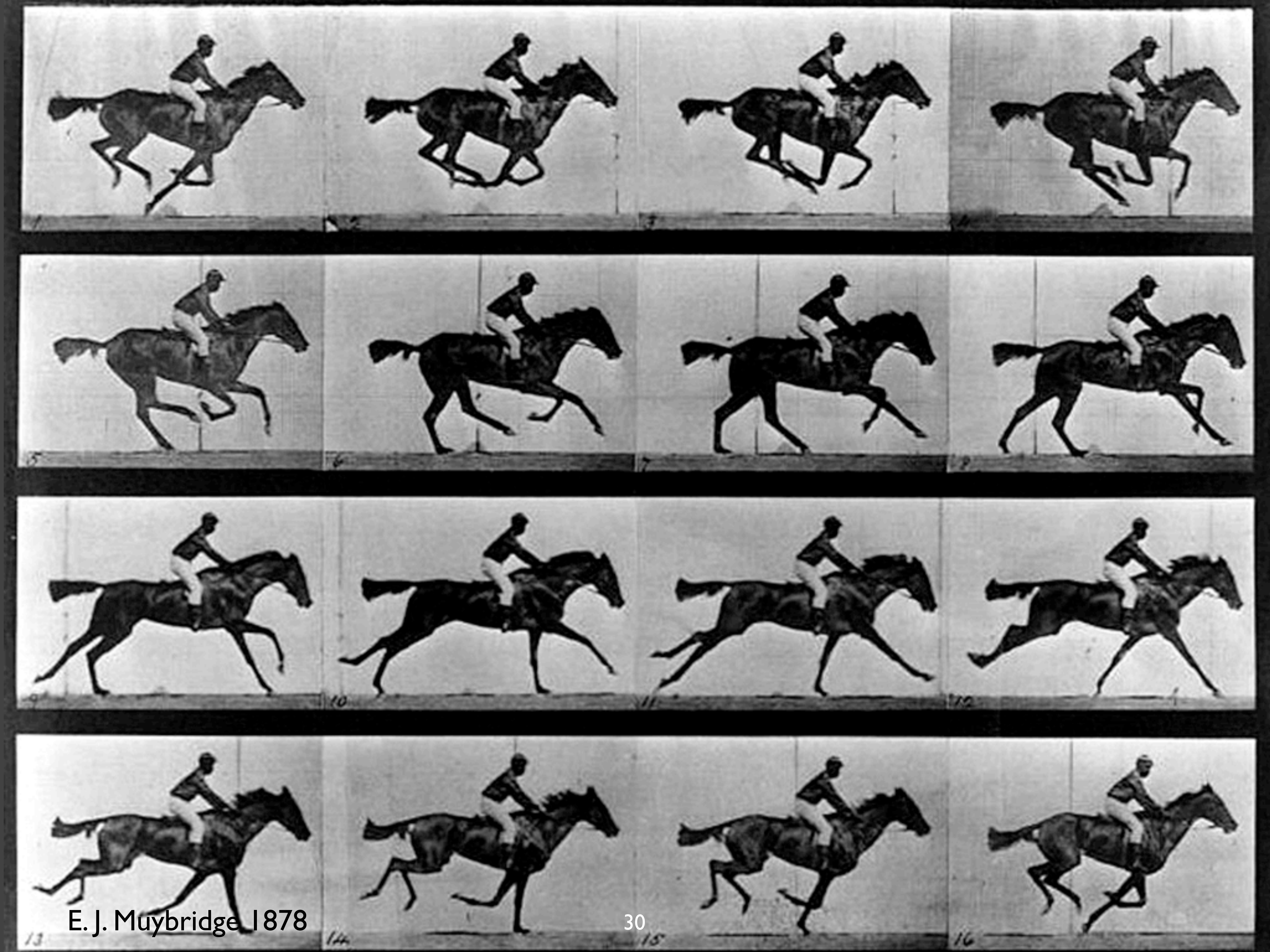
RECORD INFORMATION



Leonardo da Vinci 1485

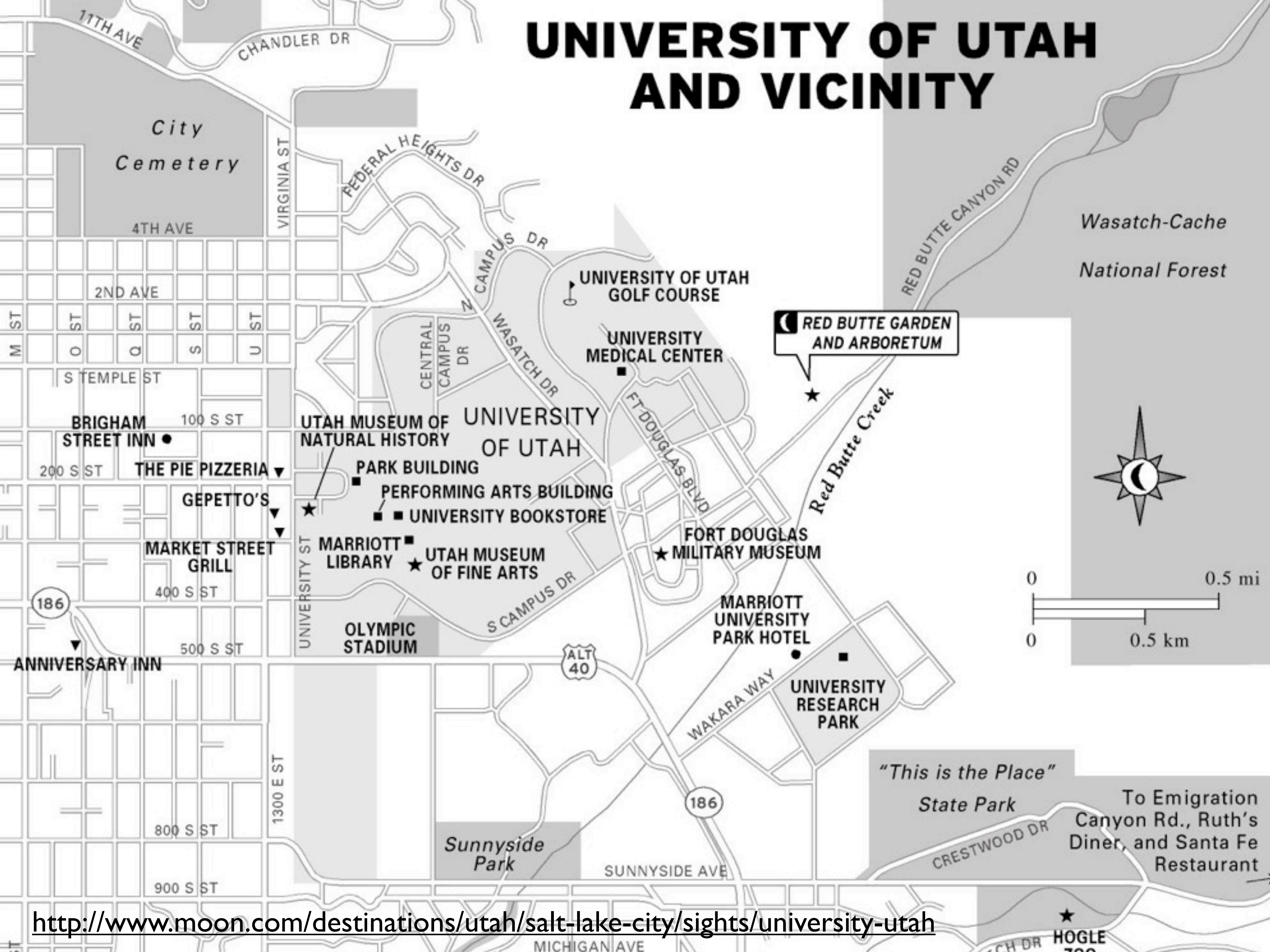
Galileo 1610





E. J. Muybridge 1878

Anne Rempel and Jonathan Barrera 2011



http://www.moon.com/destinations/utah/salt-lake-city/sights/university-utah

ANALYZE DATA

THE CHALLENGER DISASTER

http://en.wikipedia.org/wiki/File:Challenger_explosion.jpg

HISTORY OF O-RING DAMAGE ON SRM FIELD JOINTS

OCT 30, 1985 — AFT

	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)
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

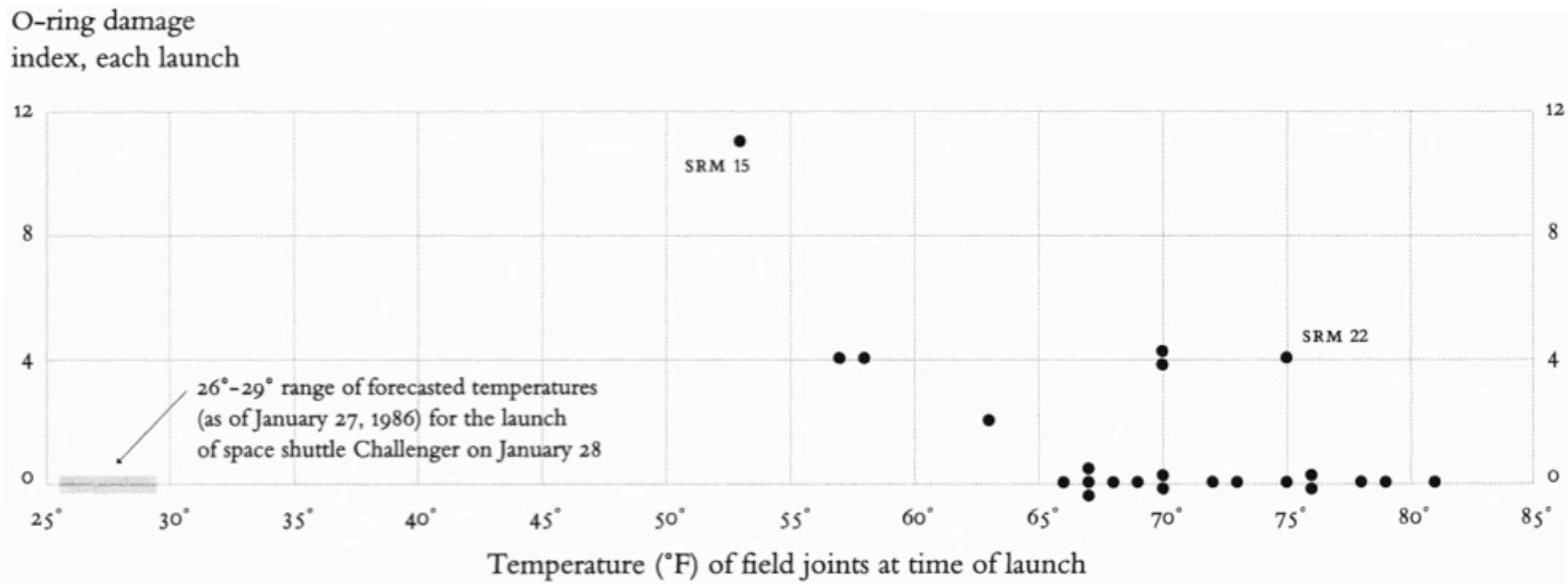
- NOZZLE BLOW-BY

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

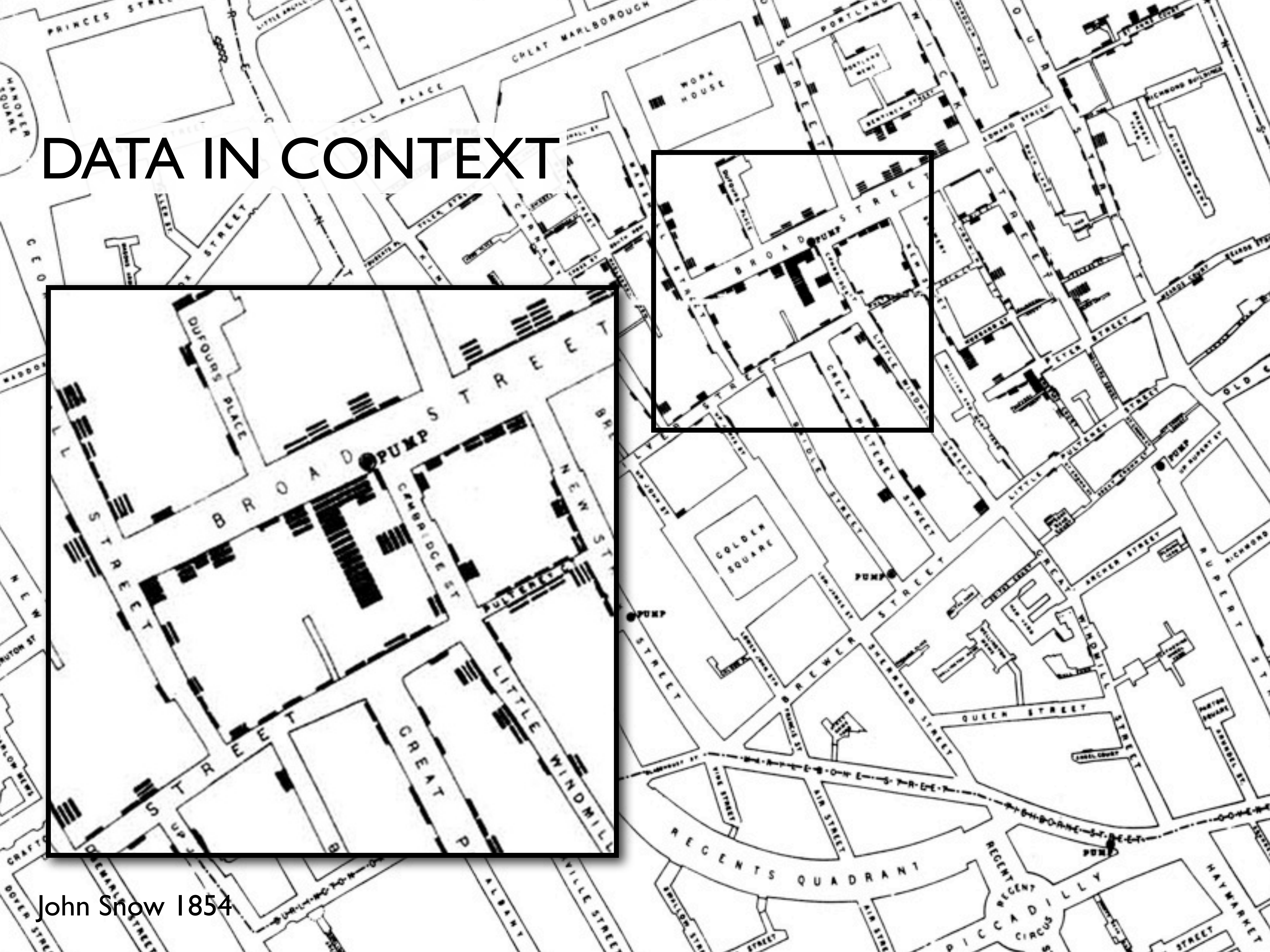
Tufte 1997

DECISION MAKING

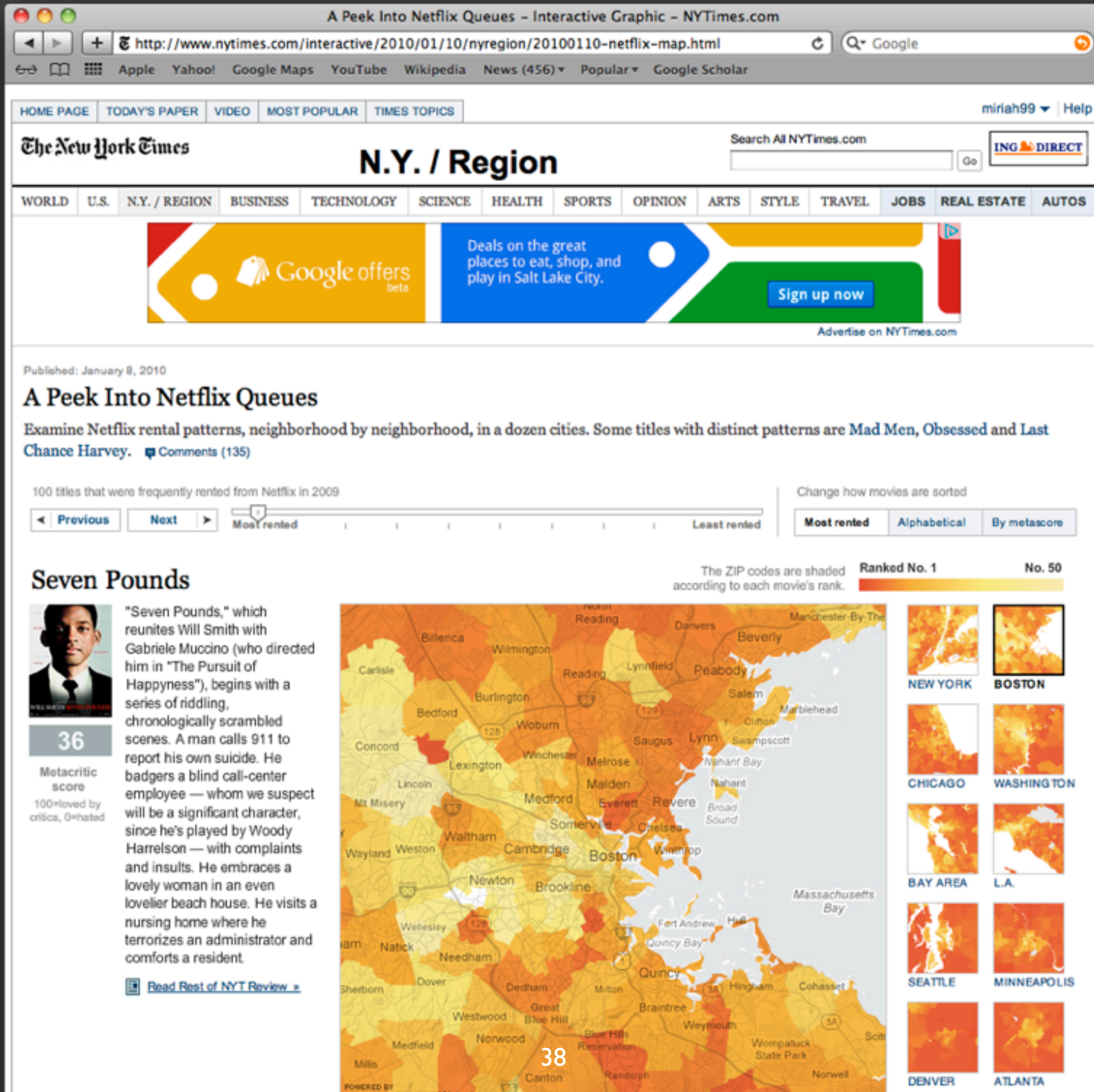


Tufte 1997

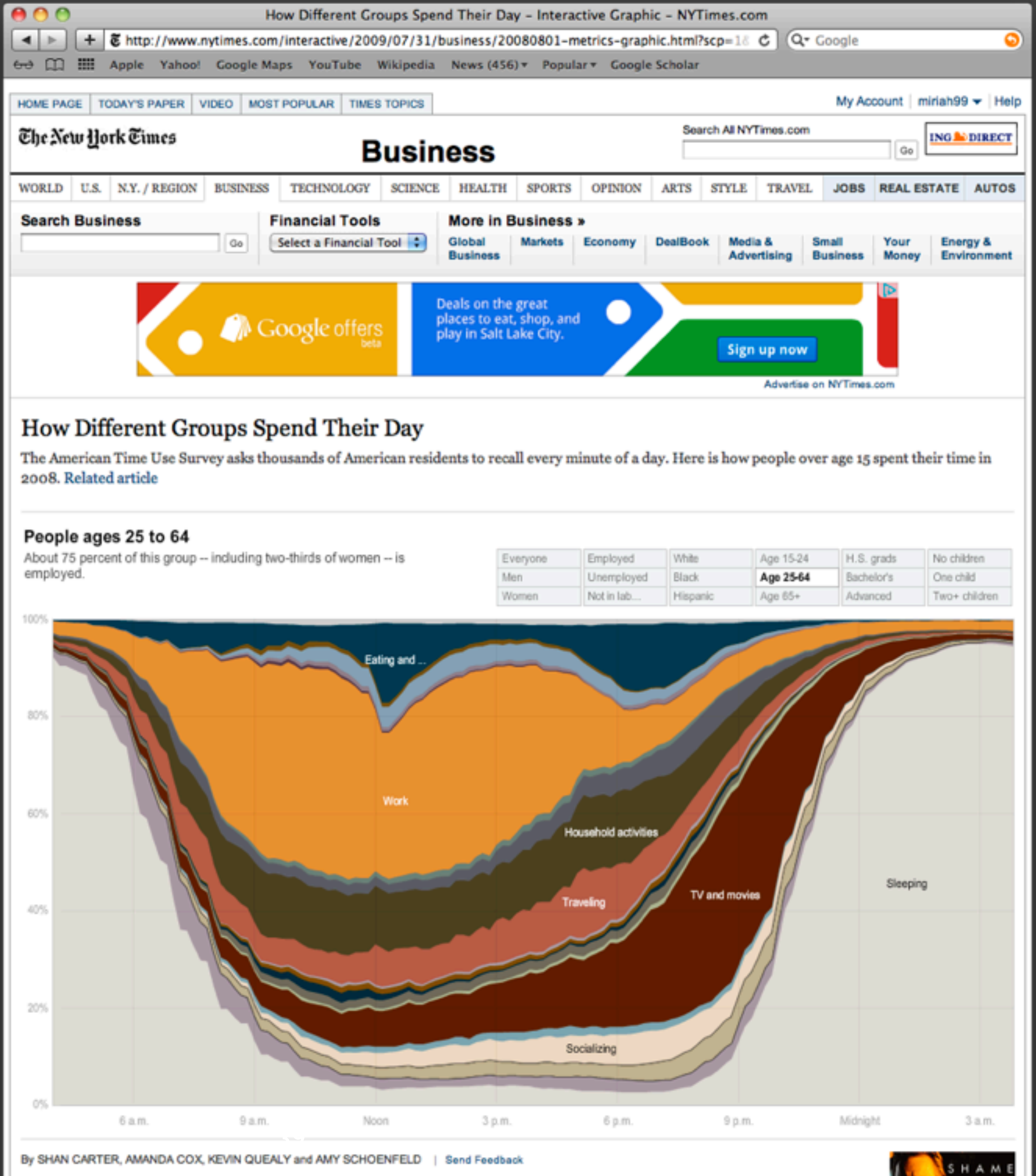
DATA IN CONTEXT



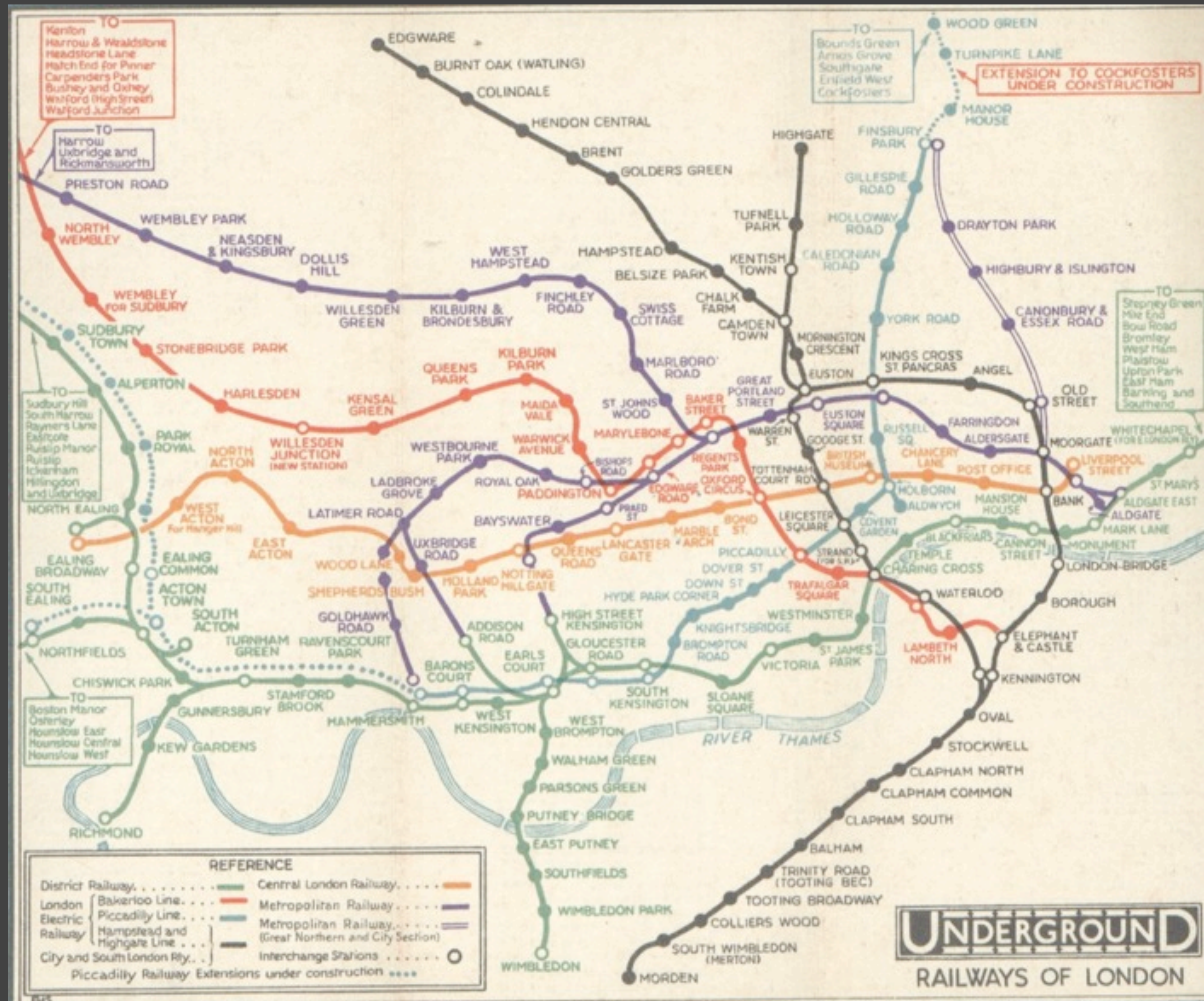
John Snow 1854


A Peek Into Netflix Queues - Interactive Graphic - NYTimes.com
http://www.nytimes.com/interactive/2010/01/10/nyregion/20100110-netflix-map.html
Google
Apple Yahoo! Google Maps YouTube Wikipedia News (456) Popular Google Scholar
HOME PAGE TODAY'S PAPER VIDEO MOST POPULAR TIMES TOPICS
miriah99 Help
The New York Times
N.Y. / Region
Search All NYTimes.com
Go
ING DIRECT
WORLD U.S. N.Y. / REGION BUSINESS TECHNOLOGY SCIENCE HEALTH SPORTS OPINION ARTS STYLE TRAVEL JOBS REAL ESTATE AUTOS
Google offers beta
Deals on the great places to eat, shop, and play in Salt Lake City.
Sign up now
Advertise on NYTimes.com
Published: January 8, 2010
A Peek Into Netflix Queues
Examine Netflix rental patterns, neighborhood by neighborhood, in a dozen cities. Some titles with distinct patterns are Mad Men, Obsessed and Last Chance Harvey.
Comments (135)
100 titles that were frequently rented from Netflix in 2009
Previous
Next
Most rented
Least rented
Change how movies are sorted
Most rented
Alphabetical
By metascore
Seven Pounds
The ZIP codes are shaded according to each movie's rank.
Ranked No. 1
No. 50
36
Metacritic score
100=loved by critics, 0=hated
"Seven Pounds," which reunites Will Smith with Gabriele Muccino (who directed him in "The Pursuit of Happyness"), begins with a series of riddling, chronologically scrambled scenes. A man calls 911 to report his own suicide. He badgers a blind call-center employee — whom we suspect will be a significant character, since he's played by Woody Harrelson — with complaints and insults. He embraces a lovely woman in an even lovelier beach house. He visits a nursing home where he terrorizes an administrator and comforts a resident.
Read Rest of NYT Review »
Reading
Danvers
Beverly
Billerica
Wilmington
Carlisle
Lynnfield
Peabody
Salem
Burlington
Bedford
Woburn
Marblehead
Concord
Saugus
Lynn
Swampscott
Winchester
Melrose
Lexington
Lincoln
Malden
Medford
Everett
Revere
Somerville
Chelsea
Waltham
Cambridge
Boston
Wayland
Weston
Newton
Brookline
Massachusetts Bay
Wellesley
Natick
Needham
Quincy
Dover
Dedham
Milton
Hingham
Cohasset
Braintree
Westwood
Weymouth
Norwood
Medfield
Canton
Randolph
Norwell
NEW YORK
BOSTON
CHICAGO
WASHINGTON
BAY AREA
L.A.
SEATTLE
MINNEAPOLIS
DENVER
ATLANTA

REVEAL PATTERNS



ABSTRACT

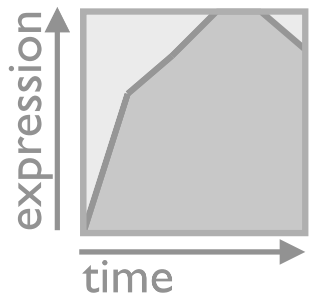


EDGWARE
BURNT OAK (WATLING)
COLINDALE
HENDON CENTRAL
BRENT
GOLDERS GREEN
HAMPSTEAD
BELSIZE PARK
CHALK FARM
CAMDEN TOWN
HIGHGATE
TUFNELL PARK
KENTISH TOWN
MORNINGTON CRESCENT
EUSTON
KINGS CROSS ST. PANCRAS
ANGEL
OLD STREET
MOORGATE
BANK
LONDON BRIDGE
BOROUGH
ELEPHANT & CASTLE
KENNINGTON
OVAL
STOCKWELL
CLAPHAM NORTH
CLAPHAM COMMON
CLAPHAM SOUTH
BALHAM
TRINITY ROAD (TOOTING BEC)
TOOTING BROADWAY
COLLIERS WOOD
SOUTH WIMBLEDON (MERTON)
MORDEN
WOOD GREEN
TURNPIKE LANE
EXTENSION TO COCKFOSTERS UNDER CONSTRUCTION
MANOR HOUSE
FINSBURY PARK
GILLESPIE ROAD
HOLLOWAY ROAD
CALEDONIAN ROAD
YORK ROAD
DRAYTON PARK
HIGHBURY & ISLINGTON
CANONBURY & ESSEX ROAD
PRESTON ROAD
WEMBLEY PARK
NEASDEN & KINGSBURY
DOLLIS HILL
WILLESDEN GREEN
KILBURN & BRONDESBURY
WEST HAMPSTEAD
FINCHLEY ROAD
SWISS COTTAGE
MARLBORO' ROAD
ST JOHNS WOOD
BAKER STREET
GREAT PORTLAND STREET
NORTH WEMBLEY
WEMBLEY FOR SUDBURY
STONEBRIDGE PARK
HARLESDEN
WILLESDEN JUNCTION (NEW STATION)
KENSAL GREEN
QUEENS PARK
KILBURN PARK
MAIDA VALE
WARWICK AVENUE
MARYLEBONE
PADDINGTON
EDGWARE ROAD
REGENTS PARK
OXFORD CIRCUS
TOTTENHAM COURT RD
LEICESTER SQUARE
TRAFALGAR SQUARE
WATERLOO
LAMBETH NORTH
SUDBURY TOWN
ALPERTON
PARK ROYAL
NORTH EALING
EALING BROADWAY
EALING COMMON
SOUTH EALING
ACTON TOWN
SOUTH ACTON
NORTHFIELDS
CHISWICK PARK
TURNHAM GREEN
GUNNERSBURY
KEW GARDENS
RICHMOND
STAMFORD BROOK
RAVENSCOURT PARK
HAMMERSMITH
BARONS COURT
WEST KENSINGTON
EARLS COURT
WEST BROMPTON
WALHAM GREEN
PARSONS GREEN
PUTNEY BRIDGE
EAST PUTNEY
SOUTHFIELDS
WIMBLEDON PARK
WIMBLEDON
NORTH ACTON
WEST ACTON
EAST ACTON
WOOD LANE
SHEPHERDS BUSH
HOLLAND PARK
NOTTING HILL GATE
QUEENS ROAD
LANCASTER GATE
MARBLE ARCH
BOND ST.
POST OFFICE
LIVERPOOL STREET
LATIMER ROAD
LADBROKE GROVE
WESTBOURNE PARK
ROYAL OAK
BAYSWATER
UXBRIDGE ROAD
GOLDHAWK ROAD
ADDISON ROAD
HIGH STREET KENSINGTON
GLOUCESTER ROAD
SOUTH KENSINGTON
SLOANE SQUARE
VICTORIA
ST JAMES PARK
WESTMINSTER
CHARING CROSS
TEMPLE
BLACKFRIARS
MANSION HOUSE
CANNON STREET
MONUMENT
MARK LANE
ALDGATE
ALDGATE EAST
ST MARYS
WHITECHAPEL
PICCADILLY
DOVER ST
DOWN ST
HYDE PARK CORNER
KNIGHTSBRIDGE
BROMPTON ROAD
HOLBORN
ALDWYCH
COVENT GARDEN
STRAND
RUSSELL SQ
BRITISH MUSEUM
CHANCERY LANE
FARRINGDON
ALDERSGATE
WARREN ST
EUSTON SQUARE
GOODGE ST
RIVER THAMES
REFERENCE
District Railway
London Electric Railway
Bakerloo Line
Piccadilly Line
Hampstead and Highgate Line
City and South London Rly.
Central London Railway
Metropolitan Railway
Metropolitan Railway (Great Northern and City Section)
Interchange Stations
Piccadilly Railway Extensions under construction
UNDERGROUND
RAILWAYS OF LONDON

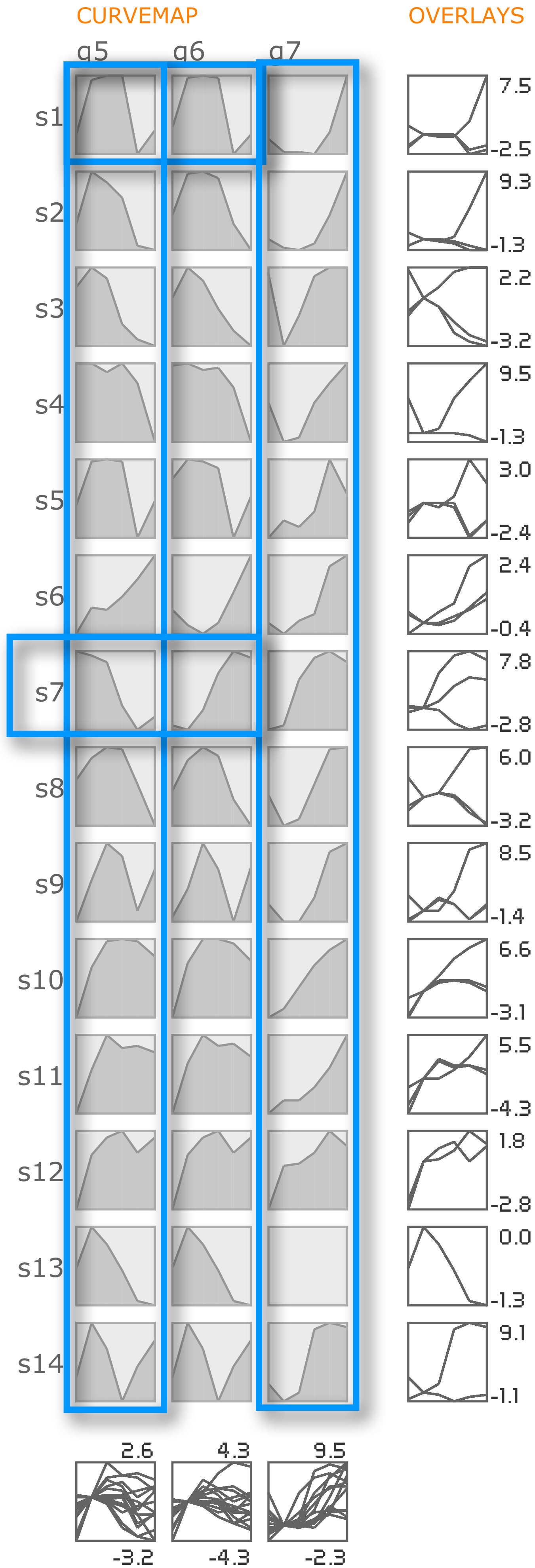
ABSTRACT


Improvement works may affect your journey, particularly at weekends. Check before you travel; look for publicity at stations, visit tfl.gov.uk/check or call 020 7222 1234
East London line is closed for major line extension work to become part of the London Overground network

CONFIRM HYPOTHESES

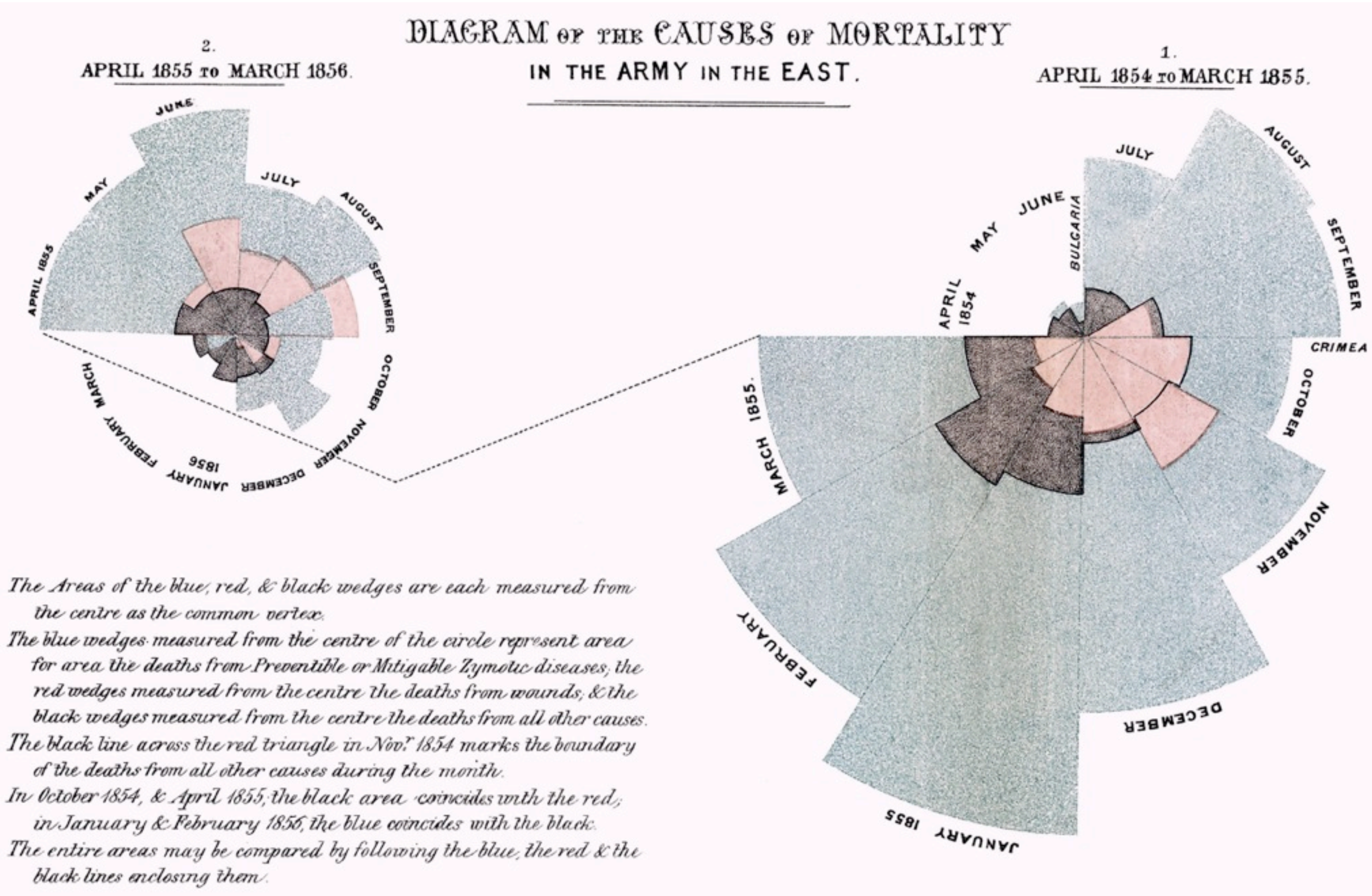


expression
time

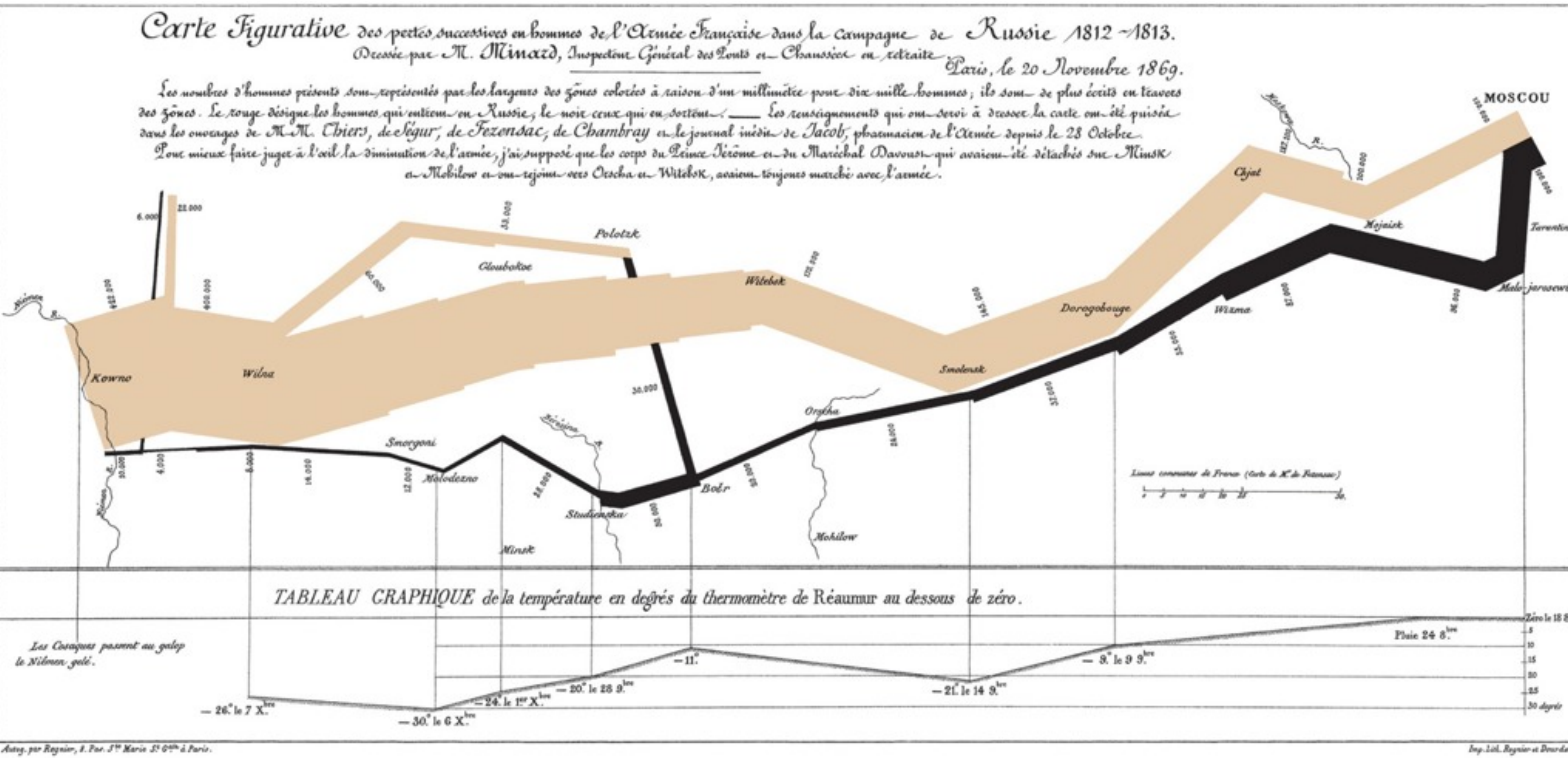


CURVEMAP
OVERLAYS
g5
g6
g7
s1
s2
s3
s4
s5
s6
s7
s8
s9
s10
s11
s12
s13
s14
7.5
-2.5
9.3
-1.3
2.2
-3.2
9.5
-1.3
3.0
-2.4
2.4
-0.4
7.8
-2.8
6.0
-3.2
8.5
-1.4
6.6
-3.1
5.5
-4.3
1.8
-2.8
0.0
-1.3
9.1
-1.1
2.6
-3.2
4.3
-4.3
9.5
-2.3

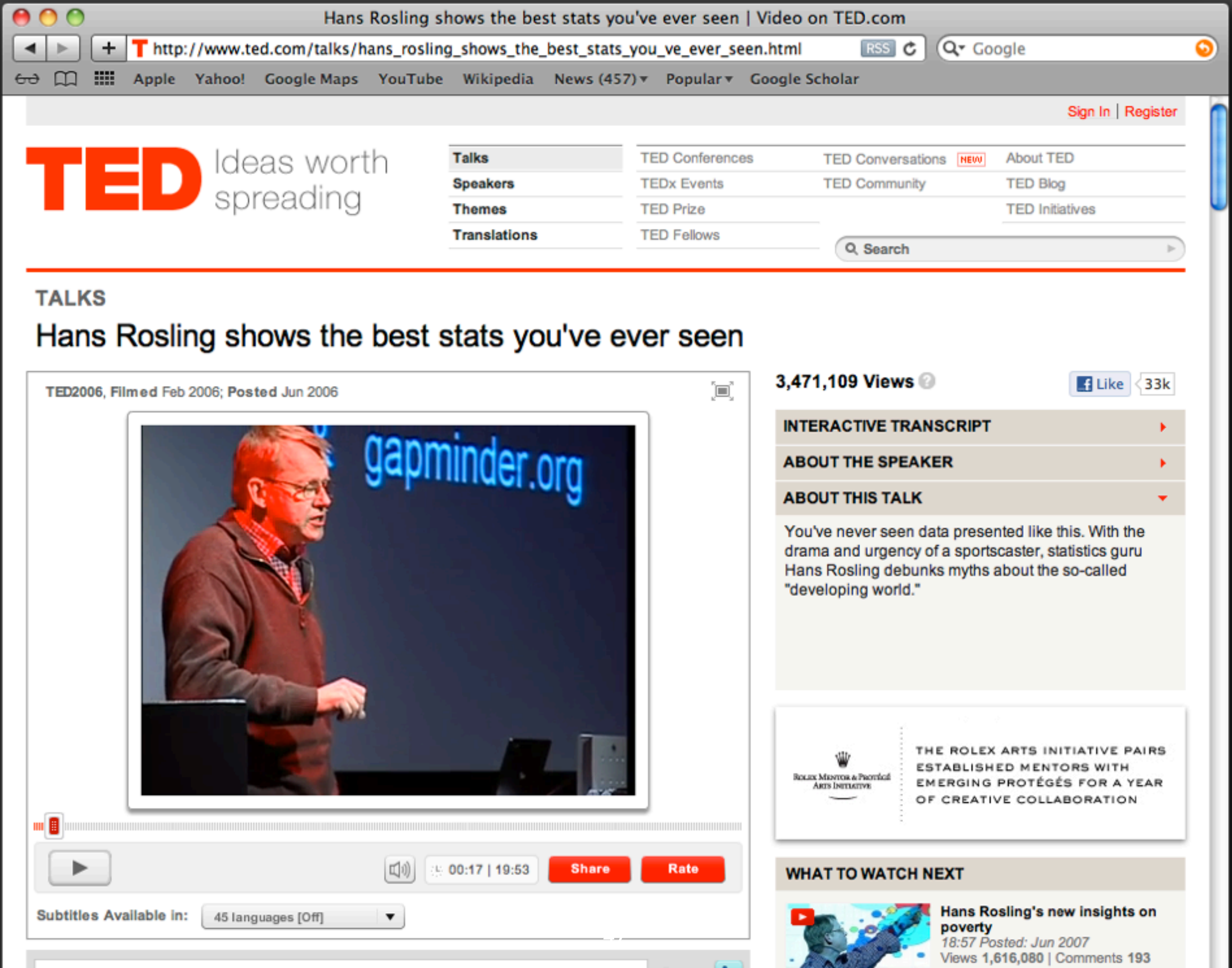
COMMUNICATE IDEAS



F. Nightingale 1856



Joseph Minard 1861


Hans Rosling shows the best stats you've ever seen | Video on TED.com
http://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen.html
RSS
Google
Apple
Yahoo!
Google Maps
YouTube
Wikipedia
News (457)
Popular
Google Scholar
Sign In | Register
TED Ideas worth spreading
Talks
Speakers
Themes
Translations
TED Conferences
TEDx Events
TED Prize
TED Fellows
TED Conversations NEW
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TALKS
Hans Rosling shows the best stats you've ever seen
TED2006, Filmed Feb 2006; Posted Jun 2006
gapminder.org
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ABOUT THE SPEAKER
ABOUT THIS TALK
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THE ROLEX ARTS INITIATIVE PAIRS ESTABLISHED MENTORS WITH EMERGING PROTÉGÉS FOR A YEAR OF CREATIVE COLLABORATION
WHAT TO WATCH NEXT
Hans Rosling's new insights on poverty
18:57 Posted: Jun 2007
Views 1,616,080 | Comments 193

RECOMMENDED READING

Tamara Munzner

27 Visualization

A major application area of computer graphics is *visualization*, where computer-generated images are used to help people understand both spatial and non-spatial data. Visualization is used when the goal is to augment human capabilities in situations where the problem is not sufficiently well defined for a computer to handle algorithmically. If a totally automatic solution can completely replace human judgement, then visualization is not typically required. Visualization can be used to generate new hypotheses when exploring a completely unfamiliar dataset, to confirm existing hypotheses in a partially understood dataset, or to present in-

DOI:10.1145/1743546.1743567

Article development led by acmqueue
queue.acm.org

A survey of powerful visualization techniques, from the obvious to the obscure.

BY JEFFREY HEER, MICHAEL BOSTOCK, AND VADIM OGIEVETSKY

A Tour Through the Visualization Zoo

THANKS TO ADVANCES in sensing, networking, and data management, our society is producing digital information at an astonishing rate. According to one estimate, in 2010 alone we will generate 1,200 exabytes—60 million times the content of the Library

The Value of Visualization

Jarke J. van Wijk*
Dept. Mathematics and Computer Science
Technische Universiteit Eindhoven

Abstract

The field of Visualization is getting mature. Many problems have been solved, and new directions are sought for. In order to make good choices, an understanding of the purpose and meaning of visualization is needed. Especially, it would be nice if we could assess what a good visualization is. In this paper an attempt is made to determine the value of visualization. A technological viewpoint is adopted, where the value of visualization is measured based on effectiveness and efficiency. An economic model of visualization is presented, and benefits and costs are established. Next, consequences for and limitations of visualization are discussed (including the use of alternative methods, high initial costs, subjectiveness, and the role of interaction), as well as examples of the use of the model for the judgement of existing classes of methods and understanding why they are or are not used in practice. Furthermore, two alternative views on visualization are presented and discussed: viewing visualization as an art or as a scientific discipline. Implications and future directions are identified.

CR Categories: H.5.2 [Information Interfaces and Presentation]: User Interfaces; I.3.6 [Computer Graphics]: Methodology and Techniques I.3.8 [Computer Graphics]: Applications

Keywords: Visualization, evaluation

1 Introduction

Modern society is confronted with a data explosion. Acquisition devices like MRI-scanners, large scale simulations on supercomputers, but also stock trading at stock exchanges produce very large amounts of data. Visualization of data makes it possible for researchers, analysts, engineers, and the lay audience to obtain insight

In this paper I want to give a contribution to the discussion on the status and possible directions of our field. Rather than to pinpoint specific topics and activities, my aim is to detect overall patterns, and to find a way to understand and qualify visualization in general. This is an ambitious and vague plan, although the basic ground for this is highly practical.

I have to make decisions on visualization in many roles. As a researcher, decisions have to be made ranging from which area to spend time on to which particular solution to implement; as a supervisor, guidance to students must be provided; as a reviewer, new results and proposals for new research must be judged, and opinions are expected if they are worth publishing or funding; as advisor in a start-up company, novel and profitable directions must be spotted. All these cases imply judgement of the value of visualization in varying senses.

How to assess the value of visualization? Visualization itself is an ambiguous term. It can refer to the research discipline, to a technology, to a specific technique, or to the visual result. If visualization is considered as a technology, i.e., as a collection of methods, techniques, and tools developed and applied to satisfy a need, then standard measures apply: Visualization has to be *effective* and *efficient*. In other words, visualization should do what it is supposed to do, and has to do this using a minimal amount of resources. One immediate and obvious implication is that we cannot judge visualization on its own, but have to take into account the context in which it is used .

In section 2 a short overview is given of the background of the topic discussed here. In section 3 an economic model of visualization is proposed. The basic elements are identified first, the associated costs and gains are added next. Various implications of the model are discussed in section 4. In section 5 this model is applied to several cases. In section 6 the model is discussed and alternative views are considered, followed by conclusions in section 7.

- WHAT
- WHY
- WHO
- HOW

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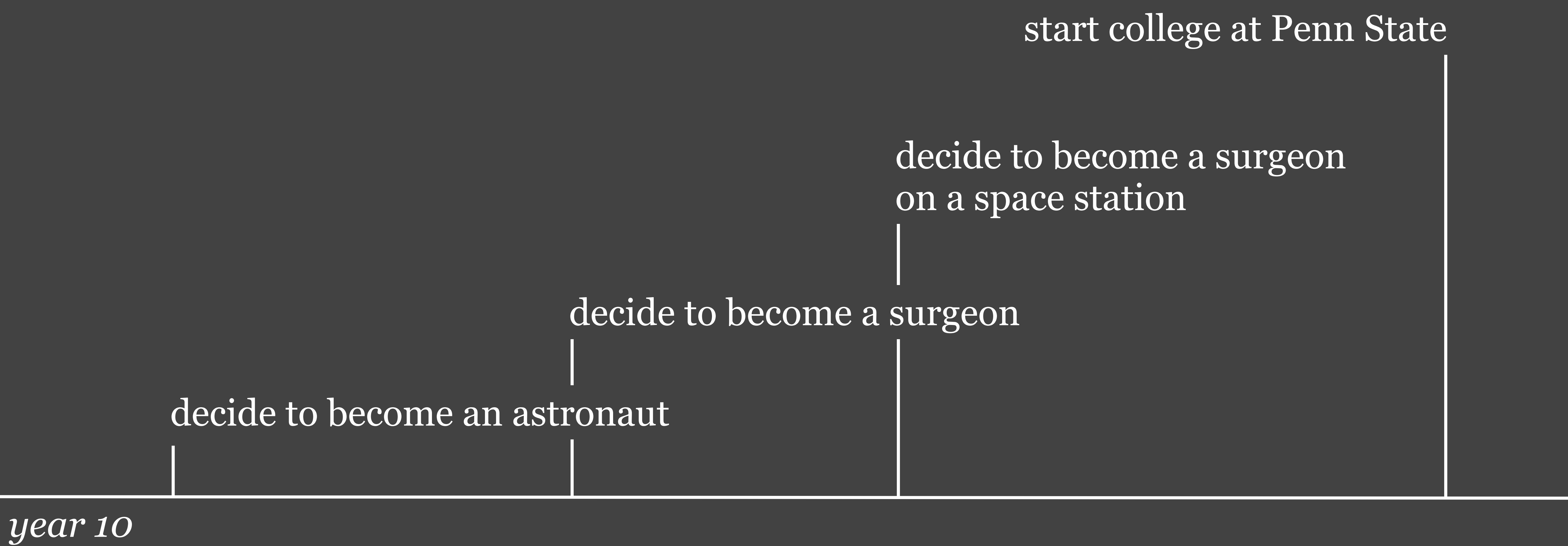
dad buys a Commodore64

born in Martinsville, VA

year 0


start college at Penn State
decide to become a surgeon
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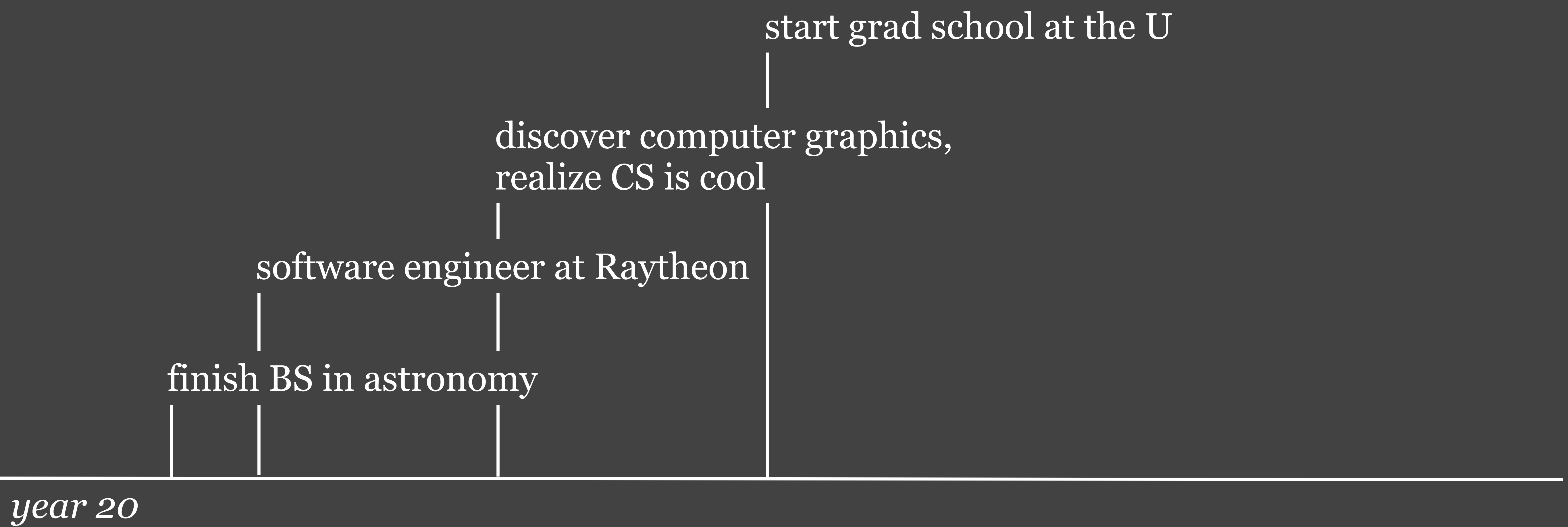
start grad school at the U
discover computer graphics,
realize CS is cool
software engineer at Raytheon
finish BS in astronomy
year 20

assistant professor at the U in
School of Computing and SCI

postdoc at Harvard University

finish PhD in computer science

year 30

YOU ARE HERE

YOU

- WHAT
- WHY
- WHO
- HOW

The **goal of this course** is to provide a framework for discussing, critiquing, and designing information visualizations.

By the end of this course you will be able to **evaluate and design** information visualizations using appropriate **vocabulary and principles**.

CONTENT

PRINCIPLES

- design
- process
- data
- visual encoding
- tasks and interaction
- abstraction

METHODS

- visual representations
- multiple views
- filtering and aggregation
- dimensionality reduction
- evaluation

A TOUR THROUGH THE ZOO

- tabular data
- graphs and trees
- text
- maps
- toolkits

GUEST LECTURES

- Jim Agutter, *Considering the Human*
- student presentations

NUTS & BOLTS

CS6964 | Information Visualization

http://www.cs.utah.edu/~miriah/cs6964/

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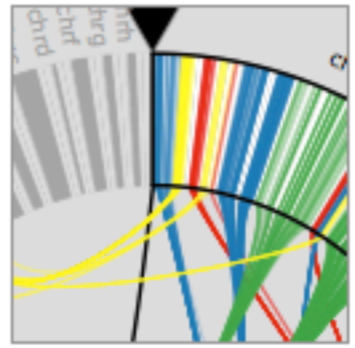
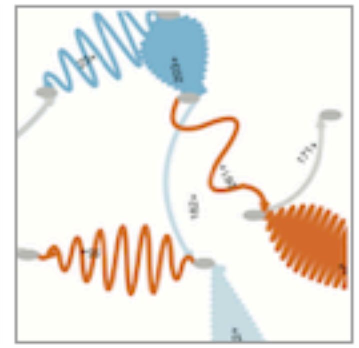
Apple Yahoo! Google Maps YouTube Wikipedia News (470) Popular Google Scholar

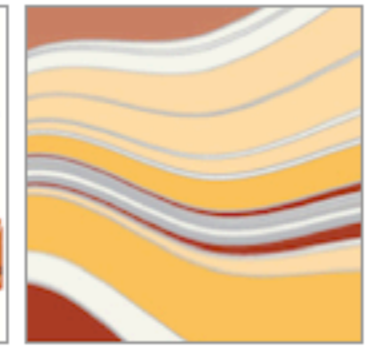
http://hci.stanford.... | 533-11: Informatio... | http://cs171.org/l... | The History of Visu... | CS6964 | Informati...

CS6964 | Information Visualization | Spring 2012

INSTRUCTOR: Miriah Meyer
TIME: T/Th 2-3:20pm
PLACE: 1450 WEB
OFFICE HRS: T 3:30-5:30pm, 4887 WEB







SCHEDULE | SYLLABUS | LECTURES | PROJECTS | PRESENTATIONS | PARTICIPATION | RESOURCES

The goal of this course is to develop a vocabulary and framework for discussing, critiquing, and designing information visualization tools. The course syllabus and schedule are still tentative and subject to change.

SCHEDULE

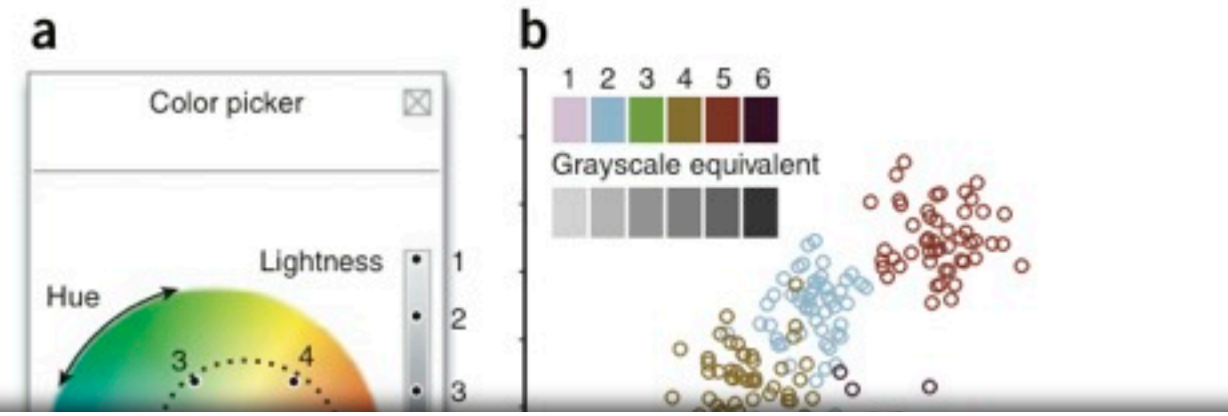
WEEK	DATE	TOPIC	DATE	TOPIC
1	1/10	Introduction	1/12	Design
2	1/17	Process	1/19	Data
3	1/24	Visual encoding	1/26	Tasks and interaction
4	1/31	Data and task abstraction 1	2/2	*no class*
5	2/7	Visual representations	2/9	Multiple views
6	2/14	Filtering and aggregation	2/16	Dimensionality reduction
7	2/21	Data and task abstraction 2	2/23	Tabular data
8	2/28	Graphs and trees	3/1	Text
9	3/6	Maps	3/8	Toolkits
10	3/12	*no class*	3/14	*no class*
11	3/20	Design studies	3/22	Considering the human
12	3/27	Project updates 1	3/29	Project updates 2
13	4/3	Project updates 3	4/5	Student presentations, tbd
14	4/10	Student presentations, tbd	4/12	Student presentations, tbd

L2: Design

REQUIRED READING

POINTS OF VIEW

Color coding



Color can add dimensionality and richness to scientific communications. In figures, color is typically used to differentiate
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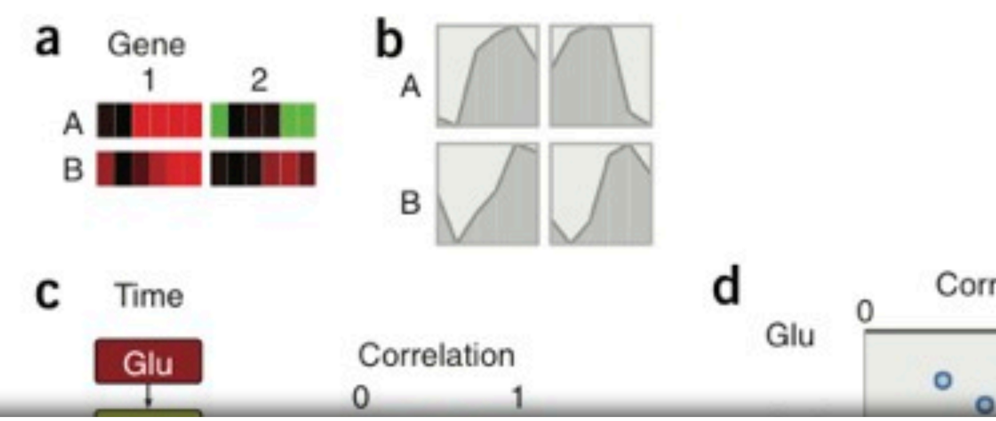
POINTS OF VIEW

Avoiding color



Last month I wrote about color blindness and ways to make information accessible to individuals with color vision deficiencies. I
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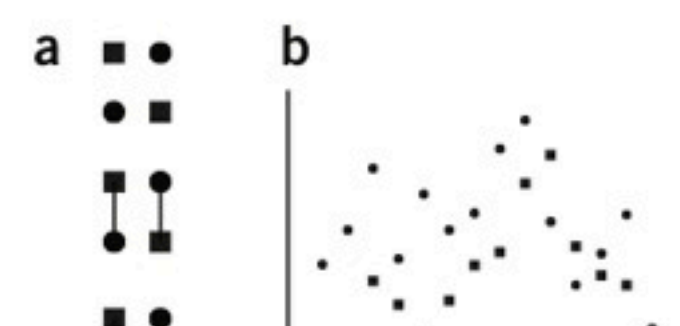
POINTS OF VIEW

Gestalt principles (Part 1)



The Decision to Launch the Space Shuttle Challenger

ON January 28, 1986, the space shuttle Challenger exploded and seven astronauts died because two rubber O-rings leaked.[22] These rings had lost their resiliency because the shuttle was launched on a very cold day. Ambient temperatures were in the low 30s and the O-rings themselves were much colder, less than 20°F.

One day before the flight, the predicted temperature for the launch was 26° to 29°. Concerned that the rings would not seal at such a cold temperature, the engineers who designed the rocket opposed launching Challenger the next day. Their misgivings derived from several sources: a history of O-ring damage during previous cool-weather launches of the shuttle, the physics of resiliency (which declines exponentially with cooling), and experimental data.[23] Presented in 13 charts, this evidence was faxed to NASA, the government agency responsible for the flight. A high-level NASA official responded that he was "appalled" by the recommendation not to launch and indicated that the rocket-maker, Morton Thiokol, should reconsider, even though this was Thiokol's only no-launch recommendation in 12 years.[24] Other NASA officials pointed out serious weaknesses in the charts. Reassessing the situation after these skeptical responses, the Thiokol managers changed their minds and decided that they now favored launching the next day. They said the evidence presented by the engineers was inconclusive, that cool temperatures were not linked to O-ring problems.[25]

Thus the *exact cause* of the accident was intensely debated during the evening before the launch. That is, for hours, the rocket engineers and managers considered the question: *Will the rubber O-rings fail catastrophically tomorrow because of the cold weather?* These discussions

[22] My sources are the five-volume *Report of the Presidential Commission on the Space Shuttle Challenger Accident* (Washington, DC, 1986) hereafter cited as *PCSSCA*; Committee on Science and Technology, House of Representatives, *Investigation of the Challenger Accident* (Washington, DC, 1986); Richard P. Feynman, "*What Do You Care What Other People Think?*" *Further Adventures of a Curious Character* (New York, 1988); Richard S. Lewis, *Challenger: The Final Voyage* (New York, 1988); Frederick Lighthall, "Launching the Space Shuttle Challenger: Disciplinary Deficiencies in the Analysis of Engineering Data," *IEEE Transactions on Engineering Management*, 38 (February 1991), pp. 63–74; and Diane Vaughan, *The Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA* (Chicago, 1996). The text accompanying the images at left is based on *PCSSCA*, volume I, pp. 6–9, 19–32, 52, 60. Illustrations of shuttle at upper left by Weilin Wu and Edward Tufte.

[23] *PCSSCA*, volume I, pp. 82–113.

[24] *PCSSCA*, volume I, p. 107.

[25] *PCSSCA*, volume I, p. 108.