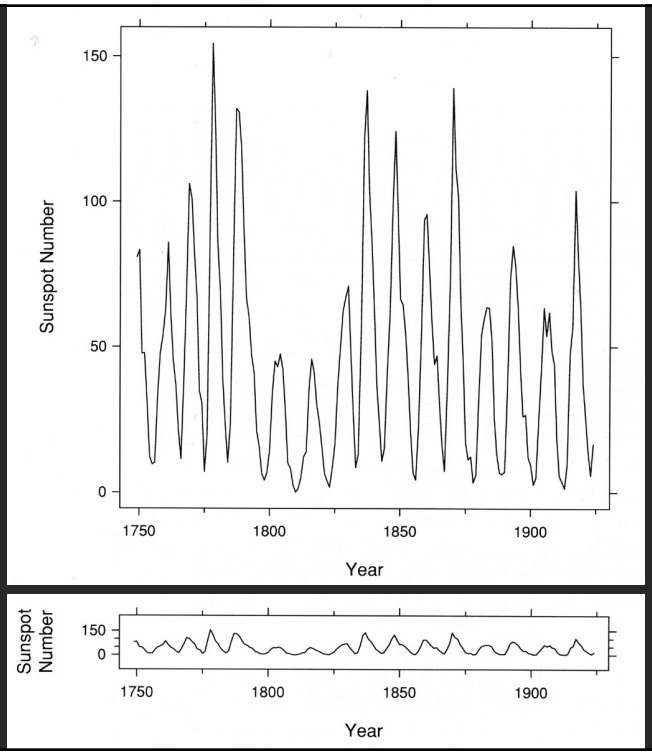
Visual Explainers

Maneesh Agrawala

CS 448B: Visualization
Fall 2018

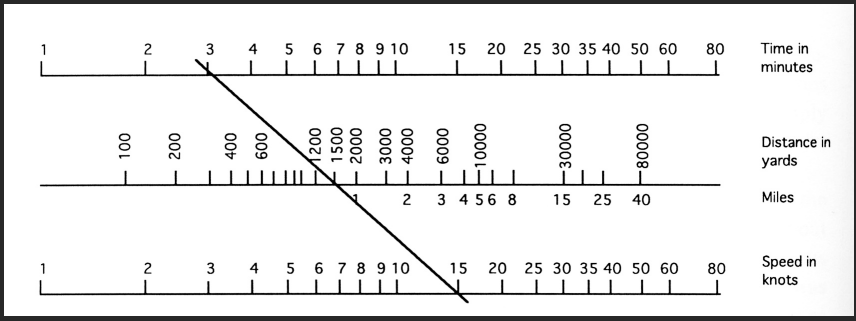
with material from Matthew Conlen and Jessica Hullman

Last Week: Using Space Effectively



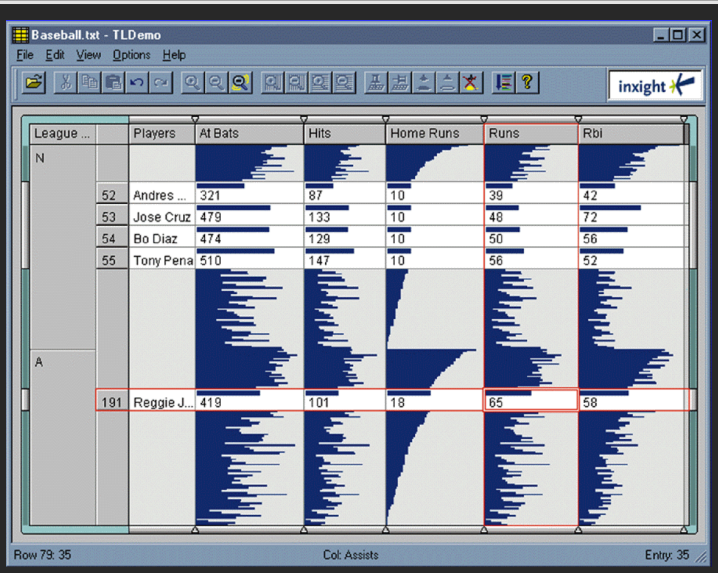
William S. Cleveland
The Elements of Graphing Data

Nomograms



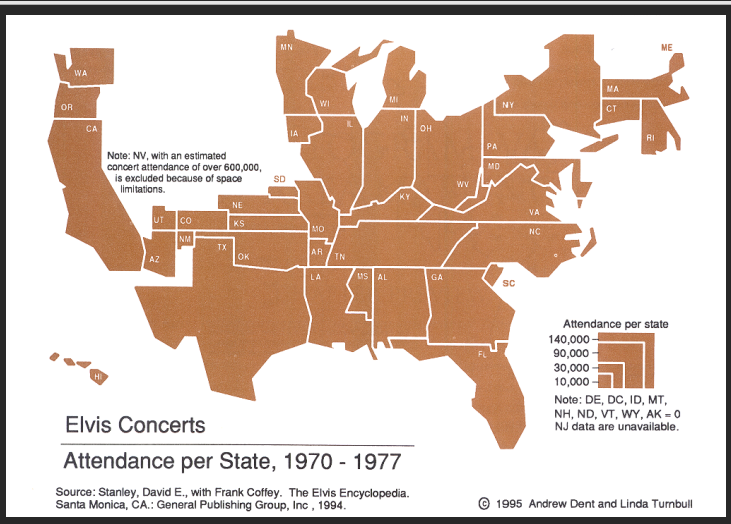
1. **Compute in any direction;** fix n-1 params and read nth param
2. **Illustrate sensitivity to perturbation of inputs**
3. **Clearly show domain of validity of computation**

TableLens [Rao & Card 94]



http://www.youtube.com/watch?v=qWqTrRAC52U

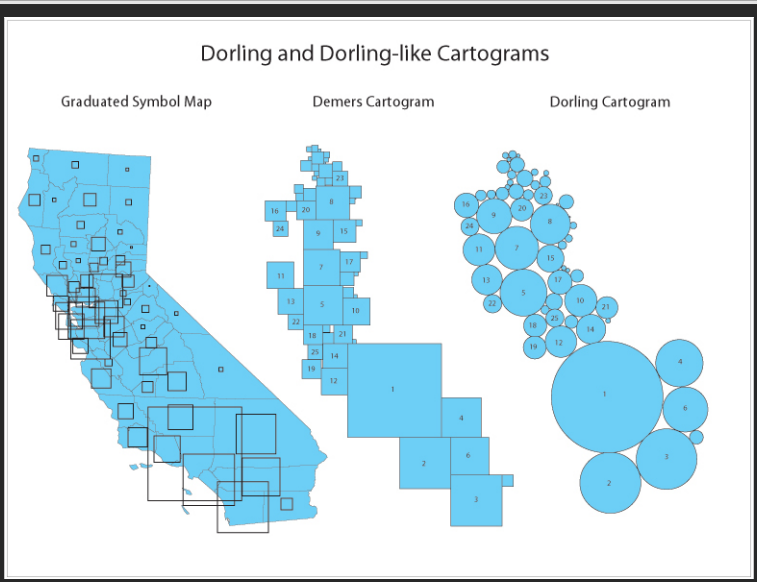
Cartograms: Distort areas



Scale area by data

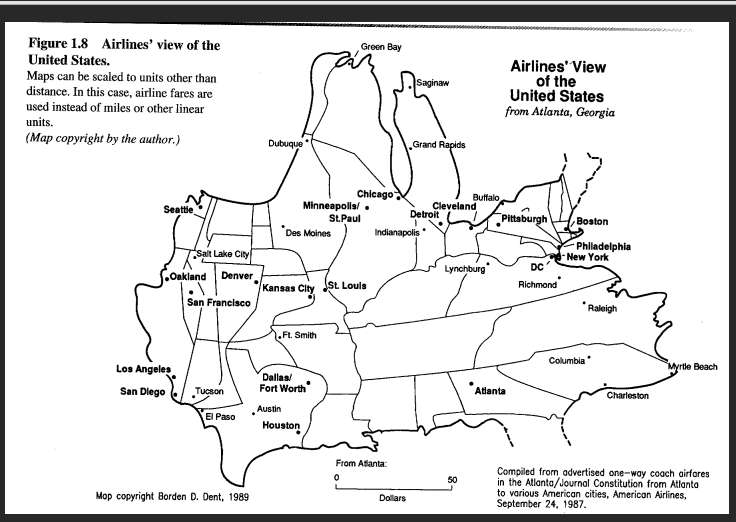
[From *Cartography*, Dent]

Dorling cartogram



http://www.ncgia.ucsb.edu/projects/Cartogram_Central/types.html

Distorting distances



Scale distance by data

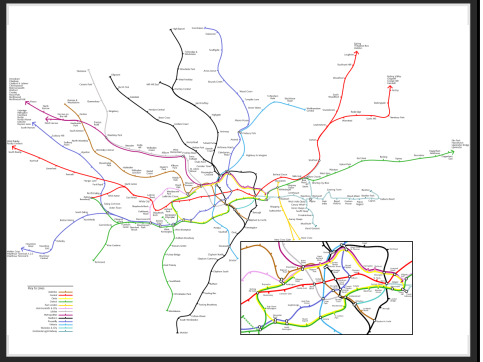
[From *Cartography*, Dent]

London underground

http://www.thetube.com/content/history/map.asp

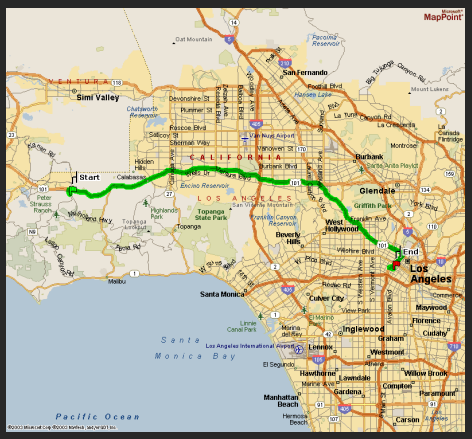
Comparison to geographic map

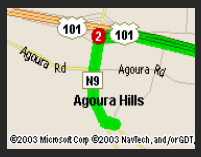
Distorted



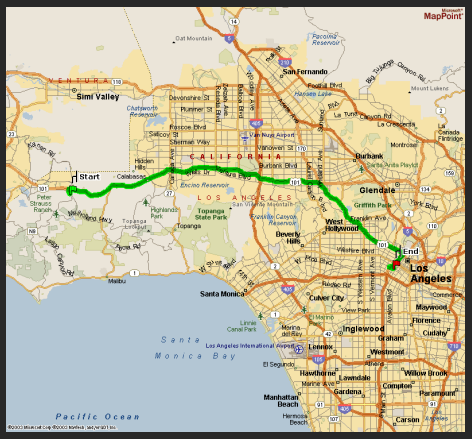
Undistorted

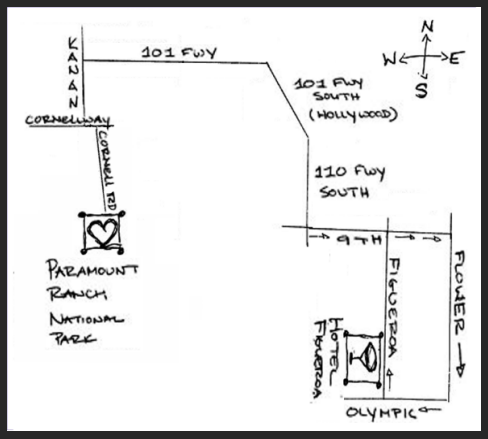
Visualizing Routes



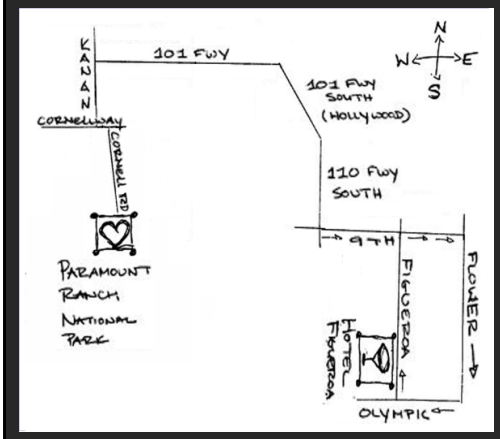


A Better Visualization

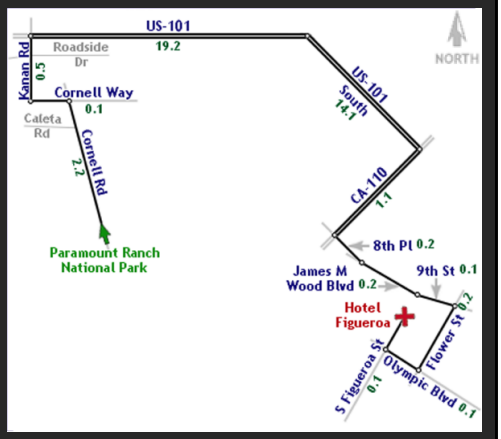




LineDrive [Agrawala & Stolte 2001]



Hand-drawn route map



LineDrive route map

Summary

- Space is the most important visual encoding
- Geometric properties of spatial transforms support geometric reasoning
- Show data with as much resolution as possible
- Use distortions to emphasize important information

Announcements

Final project

New visualization research or data analysis

- Pose problem, Implement creative solution
- Design studies/evaluations

Deliverables

- Implementation of solution
- 6-8 page paper in format of conference paper submission
- Project progress presentations

Schedule

- Project proposal: Mon 11/5
- Project progress presentation: 11/12 and 11/14 in class (3-4 min)
- Final poster presentation: 12/5 Location: Lathrop 282
- Final paper: 12/9 11:59pm

Grading

- Groups of up to 3 people, graded individually
- Clearly report responsibilities of each member

Visual Explainers

Topics

1. Storytelling
2. Design space of narrative visualization
3. Interactive documents
4. Chart sequences

Storytelling

As ancient as mankind

Going forward
I carried wax along the line, and laid it
thick on their ears. ***They tied me up****, then, plumb*
amidships, ***back to the mast****, lashed to the mast,*
and took themselves again to rowing. Soon,
as we came smartly within hailing distance,
the two ***Sirens****, noting our fast ship,*
off their point, ***made ready, and they sang****…*

All media used to tell stories

PEOPLE TELL STORIES

WORDS TELL STORIES

IMAGES TELL STORIES

COMICS TELL STORIES

MOVIES TELL STORIES

VISUALIZATIONS TELL STORIES

Narrative Storytelling

narrative (n): An account of a series of events, facts, etc., given in order and with the establishing of connections between them

"... require[s] skills like those familiar to movie directors, beyond a technical expert's knowledge of computer engineering and science."

- Gershon & Page '01

August 26, 2010

Generals Wary of Move to Cut Their Ranks

By GINGER THOMPSON and THOM SHANKER

WASHINGTON — Maj. Gen. Paul D. Eaton, a retired Army officer, is familiar with the perks and pitfalls of power, having commanded tens of thousands of troops at Fort Benning, Ga., managed budgets exceeding $2 billion in Iraq, and overseen layers upon layers of staff members who helped manage both his professional duties and his personal life.

He has experienced the full range of lifestyles that come with military leadership, living at one point in an elegant antebellum mansion, and at another, with eight other officers crowded in a marble bathhouse behind one of Saddam Hussein's old palaces.

When he traveled, he was occasionally able to justify the use of military aircraft, but most times, he said, he flew coach. And today he lives on a pension worth 75 percent of his military salary, with health benefits that cover everything except dental and eye care for himself and his wife.

"We are well compensated, and we live very comfortable lives," General Eaton said, referring to the military's most senior leaders. "But when you look at all the things going on around a general, the nation is getting a very, very high return on its money."

Not everyone at the Pentagon agrees. Two weeks ago, Defense Secretary Robert M. Gates announced a sweeping effort to improve efficiency that, among other things, takes aim at the military's sacrosanct corps of generals and admirals, ordering his staff to cut at least 50 positions, and making clear that he would be happier if they cut more.

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Anecdotal Lead

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Nut Graph

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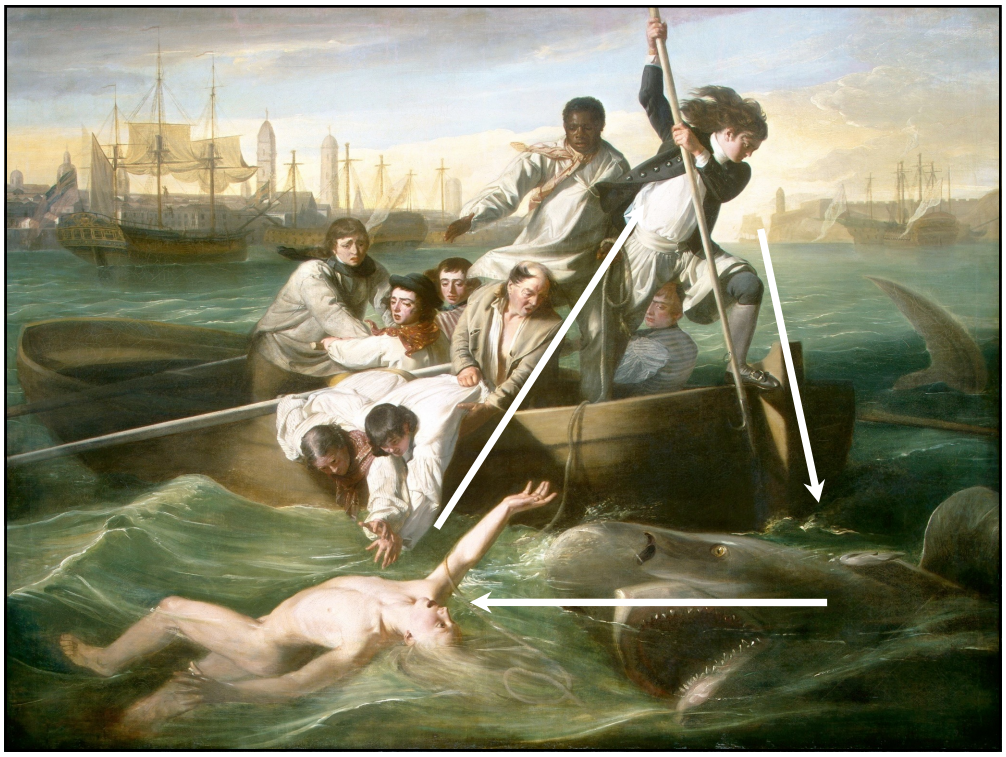
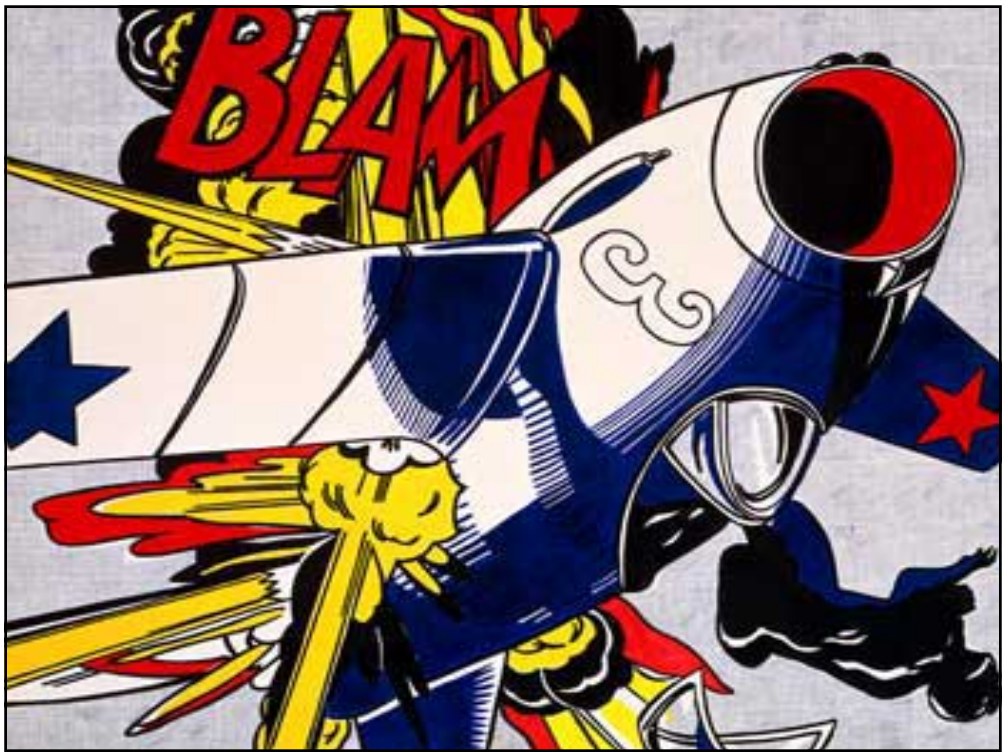
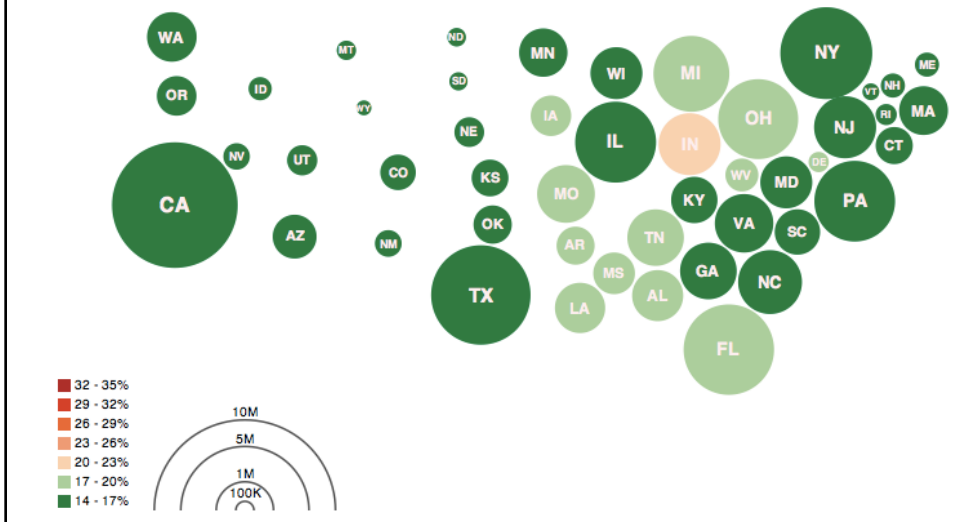
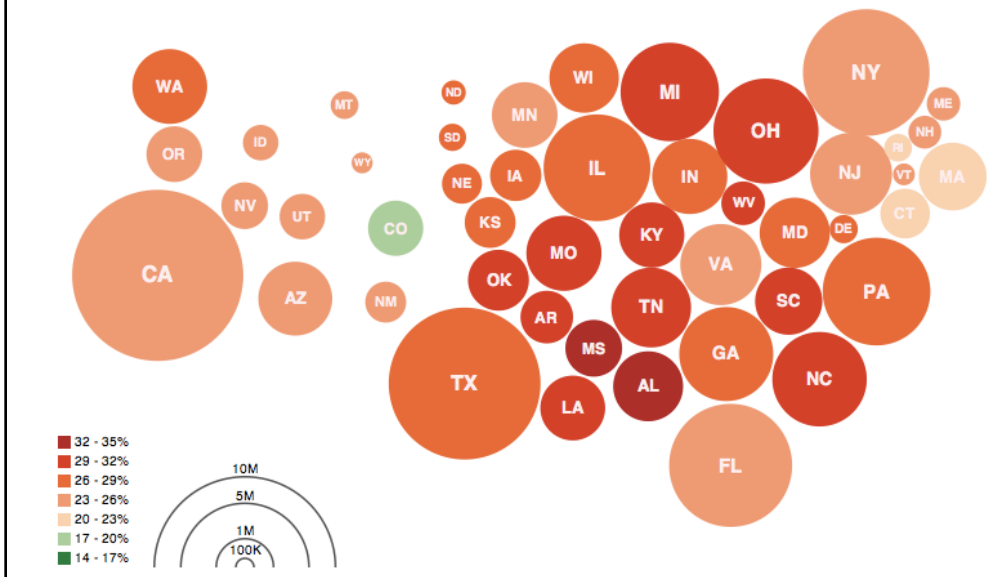


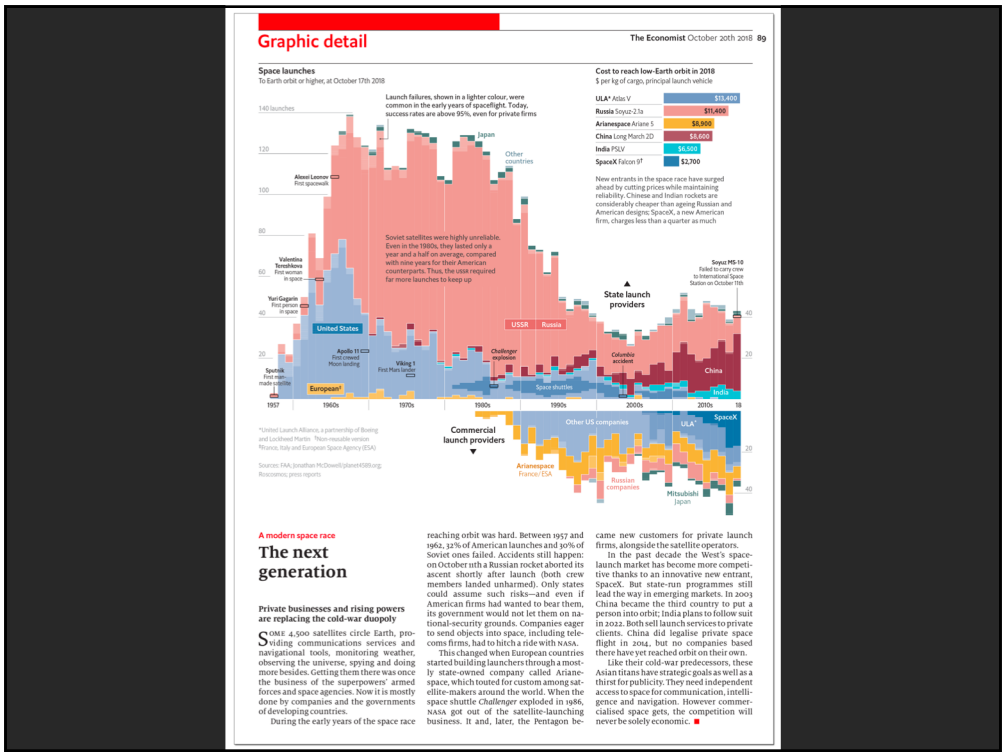

BLAM



1995 Obesity Map Vadim Ogievetsky



2008 Obesity Map Vadim Ogievetsky



Graphic detail

The Economist October 20th 2018 89

Space launches
To Earth orbit or higher, at October 17th 2018

*United Launch Alliance, a partnership of Boeing and Lockheed Martin ¹Non-reusable version ²France, Italy and European Space Agency (ESA)

Sources: FAA; Jonathan McDowell/planet4589.org; Roscosmos; press reports

Cost to reach low-Earth orbit in 2018
$ per kg of cargo, principal launch vehicle

New entrants in the space race have surged ahead by cutting prices while maintaining reliability. Chinese and Indian rockets are considerably cheaper than ageing Russian and American designs; SpaceX, a new American firm, charges less than a quarter as much

A modern space race

The next generation

Private businesses and rising powers are replacing the cold-war duopoly

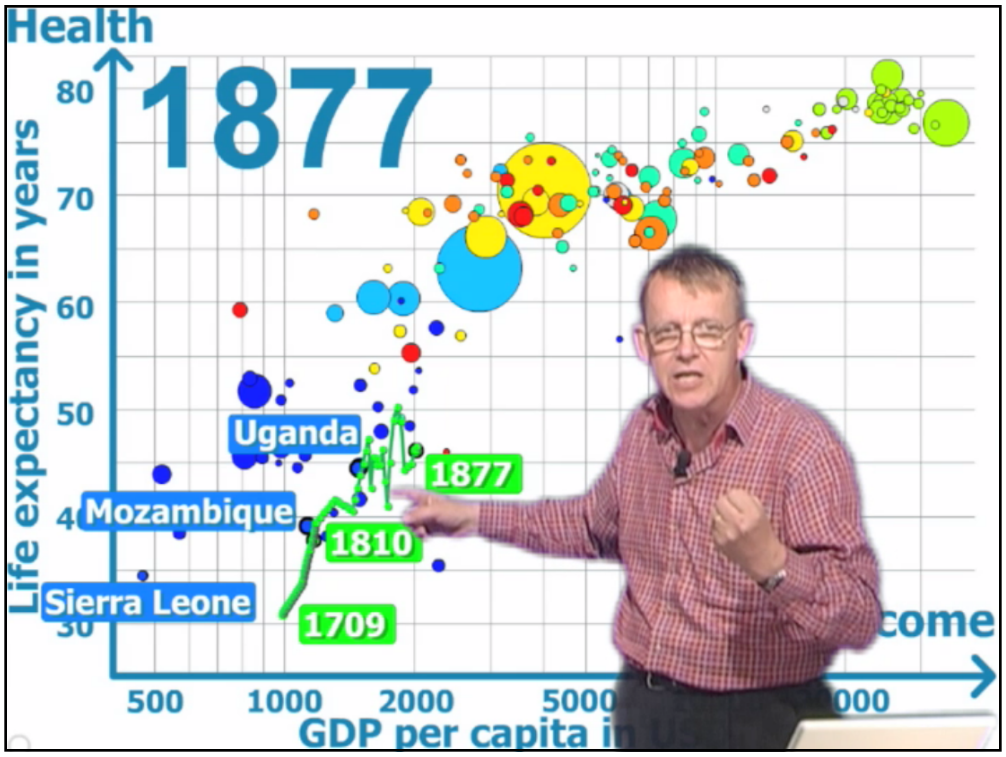
Some 4,500 satellites circle Earth, providing communications services and navigational tools, monitoring weather, observing the universe, spying and doing more besides. Getting them there was once the business of the superpowers' armed forces and space agencies. Now it is mostly done by companies and the governments of developing countries.

During the early years of the space race reaching orbit was hard. Between 1957 and 1962, 32% of American launches and 30% of Soviet ones failed. Accidents still happen: on October 11th a Russian rocket aborted its ascent shortly after launch (both crew members landed unharmed). Only states could assume such risks—and even if American firms had wanted to bear them, its government would not let them on national-security grounds. Companies eager to send objects into space, including telecoms firms, had to hitch a ride with NASA.

This changed when European countries started building launchers through a mostly state-owned company called Arianespace, which touted for custom among satellite-makers around the world. When the space shuttle *Challenger* exploded in 1986, NASA got out of the satellite-launching business. It and, later, the Pentagon became new customers for private launch firms, alongside the satellite operators.

In the past decade the West's space-launch market has become more competitive thanks to an innovative new entrant, SpaceX. But state-run programmes still lead the way in emerging markets. In 2003 China became the third country to put a person into orbit; India plans to follow suit in 2022. Both sell launch services to private clients. China did legalise private space flight in 2014, but no companies based there have yet reached orbit on their own.

Like their cold-war predecessors, these Asian titans have strategic goals as well as a thirst for publicity. They need independent access to space for communication, intelligence and navigation. However commercialised space gets, the competition will never be solely economic. ■

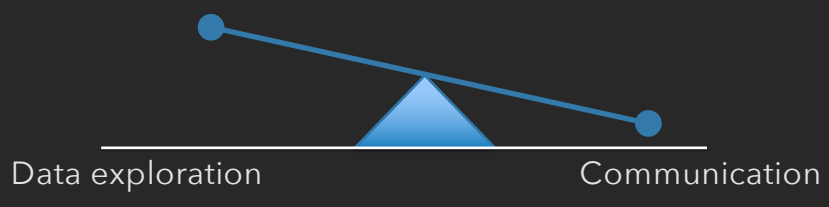


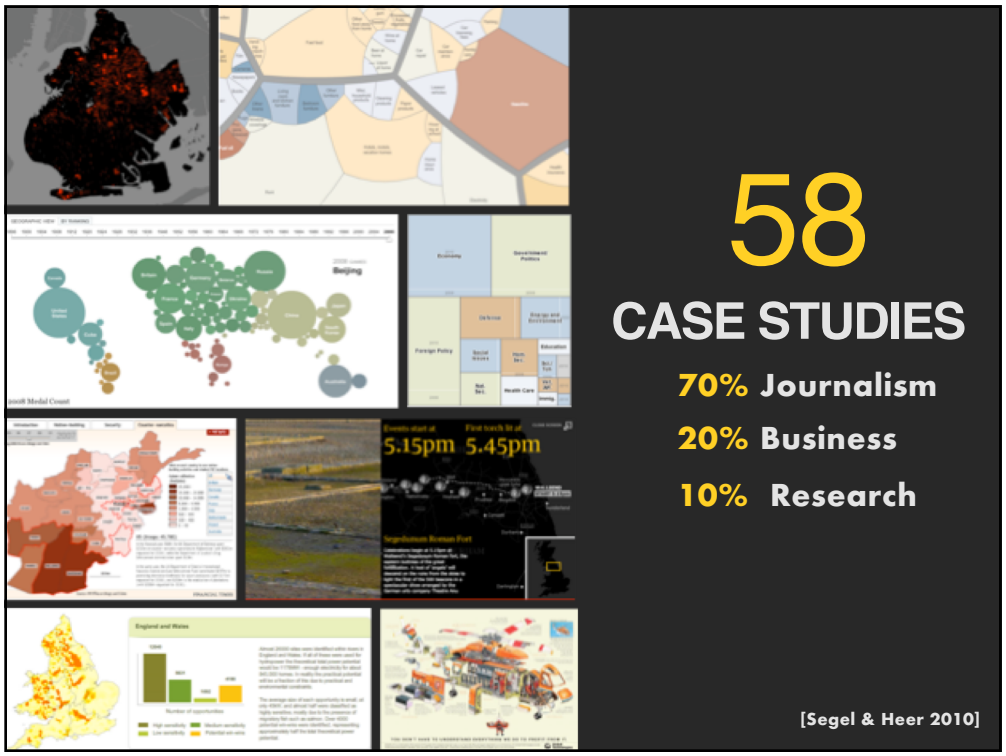
Design Space of Narrative Visualization

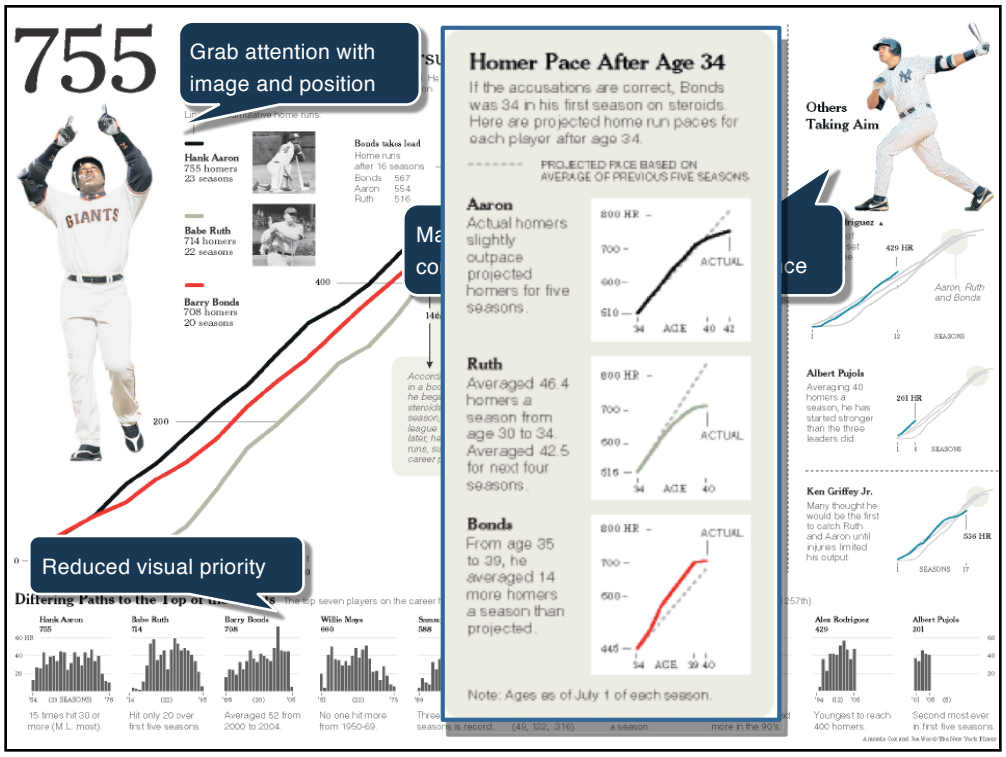
Value of storytelling [Gershon and Page 2001]

A way of structuring information

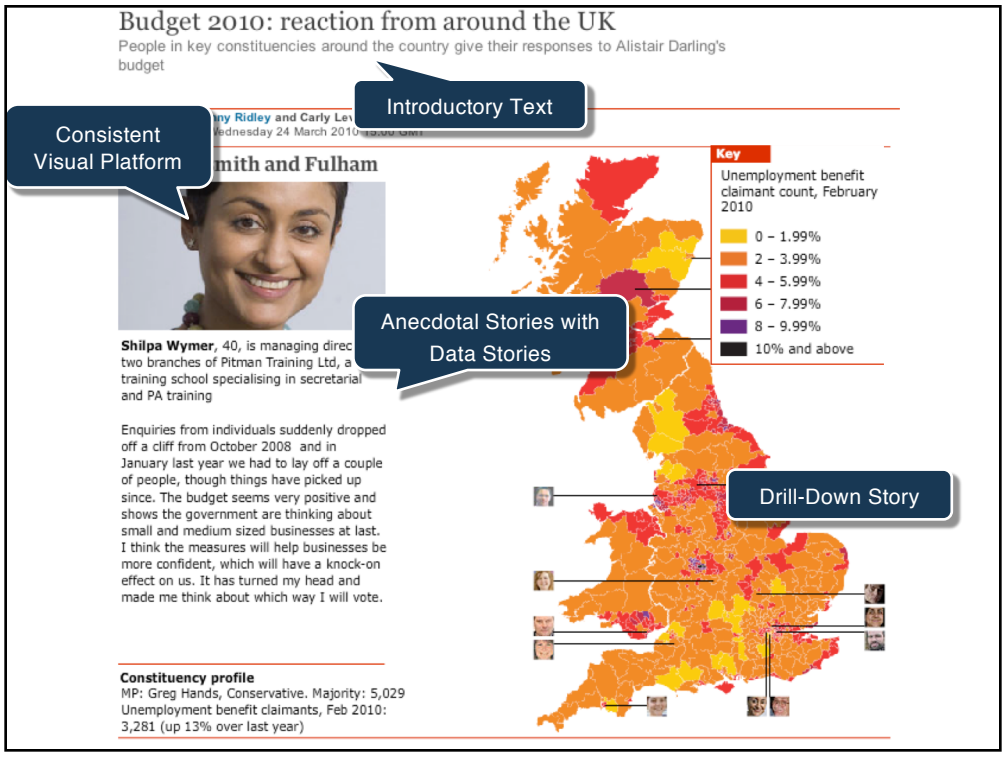
- Easier to understand than lists
- Uncertainty, conflict, resolution
- Text and visuals can be complementary

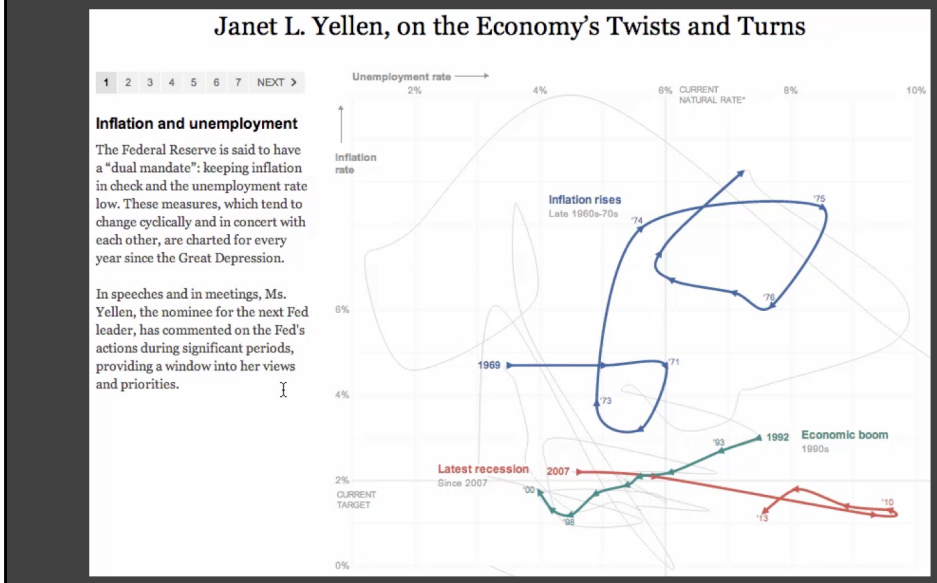


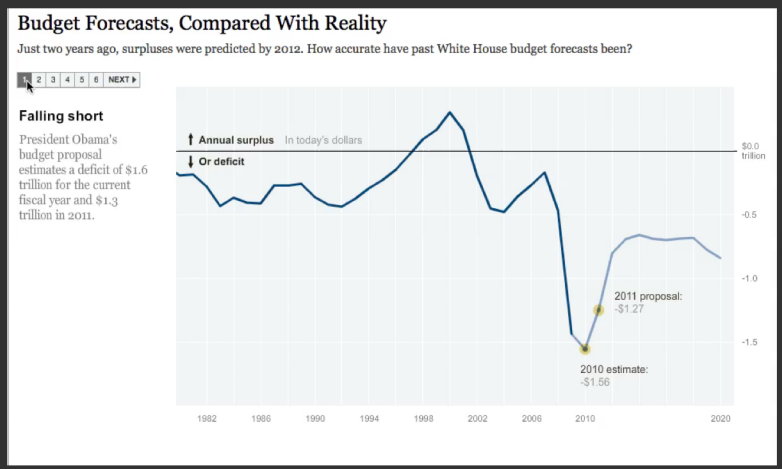

58
CASE STUDIES
70% Journalism
20% Business
10% Research
[Segel & Heer 2010]

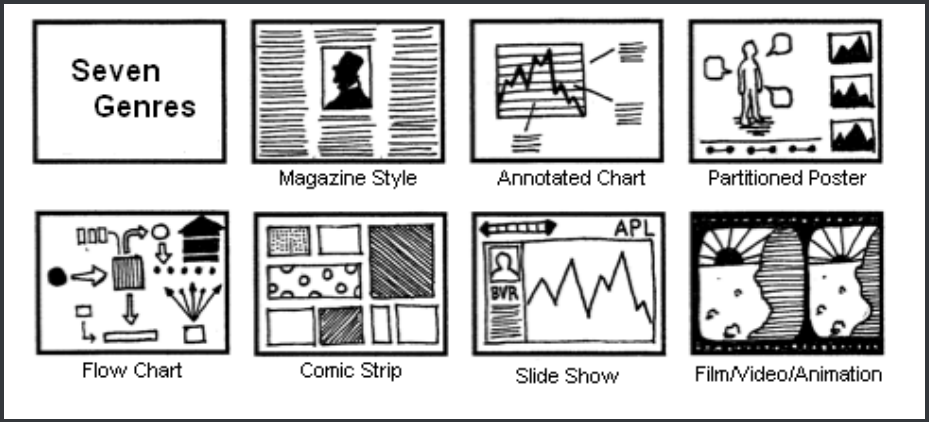

755
Grab attention with image and position
Homer Pace After Age 34
If the accusations are correct, Bonds was 34 in his first season on steroids. Here are projected home run paces for each player after age 34.
PROJECTED PACE BASED ON AVERAGE OF PREVIOUS FIVE SEASONS
Aaron
Actual homers slightly outpace projected homers for five seasons.
Ruth
Averaged 46.4 homers a season from age 30 to 34. Averaged 42.5 for next four seasons.
Bonds
From age 35 to 39, he averaged 14 more homers a season than projected.
ACTUAL
AGE
Note: Ages as of July 1 of each season.
Others Taking Aim
Aaron, Ruth and Bonds
Albert Pujols
Ken Griffey Jr.
Reduced visual priority
Differing Paths to the Top of th
Hank Aaron
Babe Ruth
Barry Bonds
Willie Mays
Alex Rodriguez
Albert Pujols

Beginning
Middle
End
Epilogue
755
Steroids or Not, the Pursuit Is On
Others Taking Aim
Homer Pace After Age 34
Differing Paths to the Top of the Charts

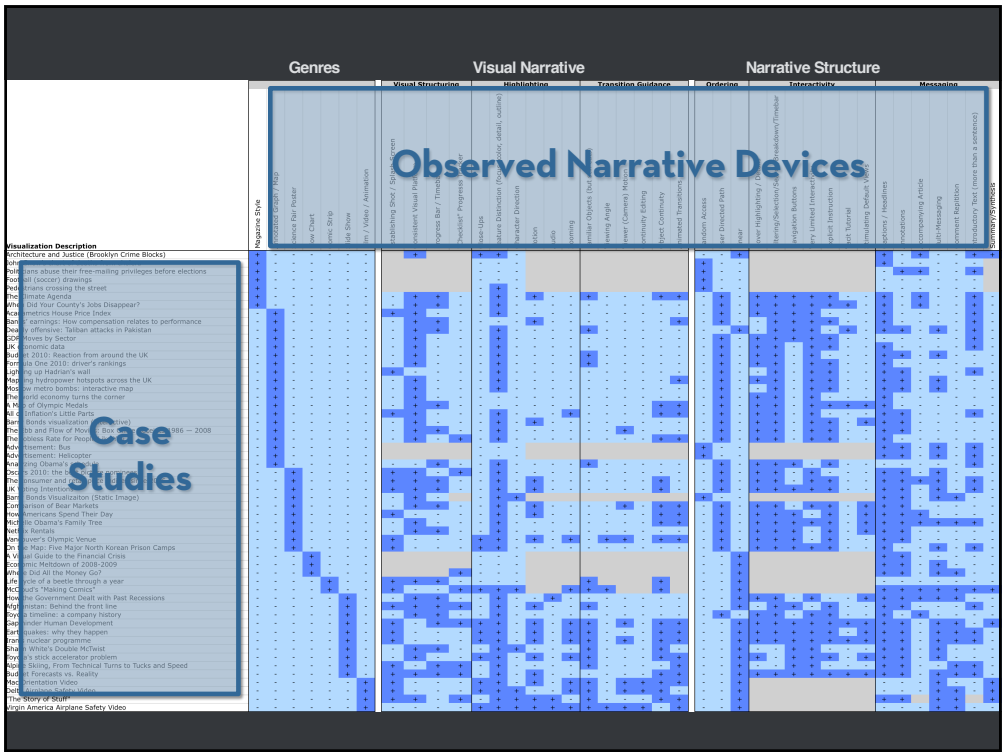

Budget 2010: reaction from around the UK
People in key constituencies around the country give their responses to Alistair Darling's budget
Introductory Text
Consistent Visual Platform
Anecdotal Stories with Data Stories
Drill-Down Story
Key
Unemployment benefit claimant count, February 2010
0 – 1.99%
2 – 3.99%
4 – 5.99%
6 – 7.99%
8 – 9.99%
10% and above
Shilpa Wymer, 40, is managing direc
two branches of Pitman Training Ltd, a
training school specialising in secretarial
and PA training
Enquiries from individuals suddenly dropped off a cliff from October 2008 and in January last year we had to lay off a couple of people, though things have picked up since. The budget seems very positive and shows the government are thinking about small and medium sized businesses at last. I think the measures will help businesses be more confident, which will have a knock-on effect on us. It has turned my head and made me think about which way I will vote.
Constituency profile
MP: Greg Hands, Conservative. Majority: 5,029
Unemployment benefit claimants, Feb 2010: 3,281 (up 13% over last year)

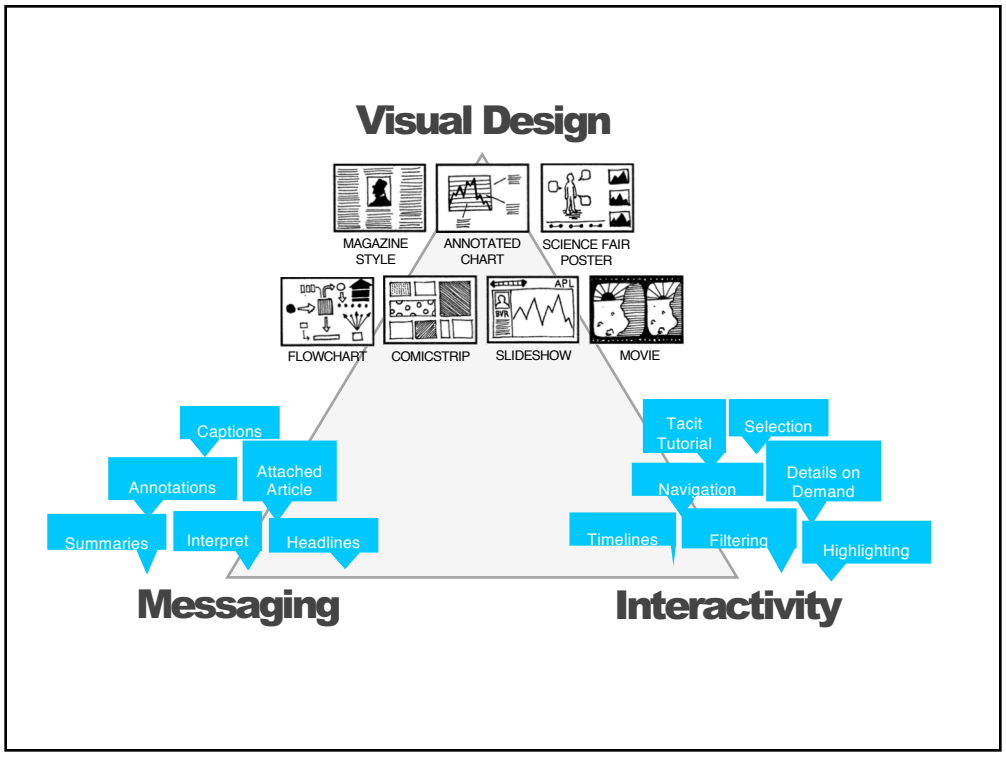

Janet L. Yellen, on the Economy's Twists and Turns
1 2 3 4 5 6 7 NEXT
Inflation and unemployment
The Federal Reserve is said to have a "dual mandate": keeping inflation in check and the unemployment rate low. These measures, which tend to change cyclically and in concert with each other, are charted for every year since the Great Depression.
In speeches and in meetings, Ms. Yellen, the nominee for the next Fed leader, has commented on the Fed's actions during significant periods, providing a window into her views and priorities.
Unemployment rate
2%
4%
6% CURRENT NATURAL RATE*
8%
10%
Inflation rate
Inflation rises
Late 1960s-70s
'74
'75
'76
1969
'71
'73
6%
4%
'93
1992
Economic boom
1990s
Latest recession
Since 2007
2007
'00
'98
'10
'13
2%
CURRENT TARGET
0%


Budget Forecasts, Compared With Reality
Just two years ago, surpluses were predicted by 2012. How accurate have past White House budget forecasts been?
1 2 3 4 5 6 NEXT
Falling short
President Obama's budget proposal estimates a deficit of $1.6 trillion for the current fiscal year and $1.3 trillion in 2011.
Annual surplus In today's dollars
Or deficit
$0.0 trillion
-0.5
-1.0
-1.5
2011 proposal:
-$1.27
2010 estimate:
-$1.56
1982
1986
1990
1994
1998
2002
2006
2010
2020



Genres for Narrative Visualization (Segel & Heer 2010)

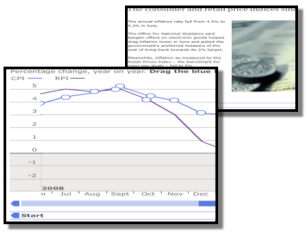

Genres
Visual Narrative
Narrative Structure
Observed Narrative Devices
Case Studies


Visual Design
MAGAZINE STYLE
ANNOTATED CHART
SCIENCE FAIR POSTER
FLOWCHART
COMICSTRIP
SLIDESHOW
MOVIE
Captions
Annotations
Attached Article
Summaries
Interpret
Headlines
Tacit Tutorial
Selection
Navigation
Details on Demand
Timelines
Filtering
Highlighting
Messaging
Interactivity

Genres + Interactivity + Messaging =

DESIGN SPACE

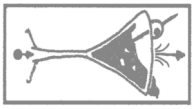
STORYTELLING CLARITY SPEED	**Author Driven** strong ordering heavy messaging limited interactivity	**Reader Driven** weak ordering light messaging free interactivity	ASK QUESTIONS EXPLORE FIND

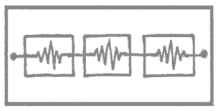


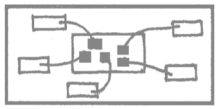
martini glass

interactive slideshow

drill-down story





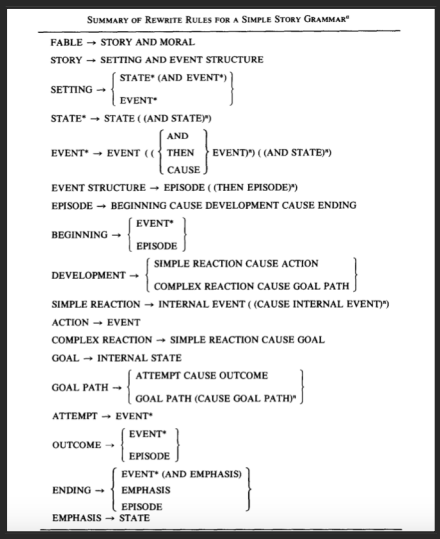


Narrative theory

Story grammars:

Models of narrative cognition based on systematic studies of what impacts peoples' ability to recall parts of a story

Reader mentally indexes events by time, space, protagonist, causality, intention [Zwaan 1995]



SUMMARY OF REWRITE RULES FOR A SIMPLE STORY GRAMMAR[a]

FABLE → STORY AND MORAL

STORY → SETTING AND EVENT STRUCTURE

SETTING → { STATE* (AND EVENT*) / EVENT* }

STATE* → STATE ((AND STATE)*)

EVENT* → EVENT (({ AND / THEN / CAUSE } EVENT)*) ((AND STATE)*)

EVENT STRUCTURE → EPISODE ((THEN EPISODE)*)

EPISODE → BEGINNING CAUSE DEVELOPMENT CAUSE ENDING

BEGINNING → { EVENT* / EPISODE }

DEVELOPMENT → { SIMPLE REACTION CAUSE ACTION / COMPLEX REACTION CAUSE GOAL PATH }

SIMPLE REACTION → INTERNAL EVENT ((CAUSE INTERNAL EVENT)*)

ACTION → EVENT

COMPLEX REACTION → SIMPLE REACTION CAUSE GOAL

GOAL → INTERNAL STATE

GOAL PATH → { ATTEMPT CAUSE OUTCOME / GOAL PATH (CAUSE GOAL PATH)* }

ATTEMPT → EVENT*

OUTCOME → { EVENT* / EPISODE }

ENDING → { EVENT* (AND EMPHASIS) / EMPHASIS / EPISODE }

EMPHASIS → STATE

Remembrance of Things Parsed [Mandler and Johnson 1977]

Narrative theory applied

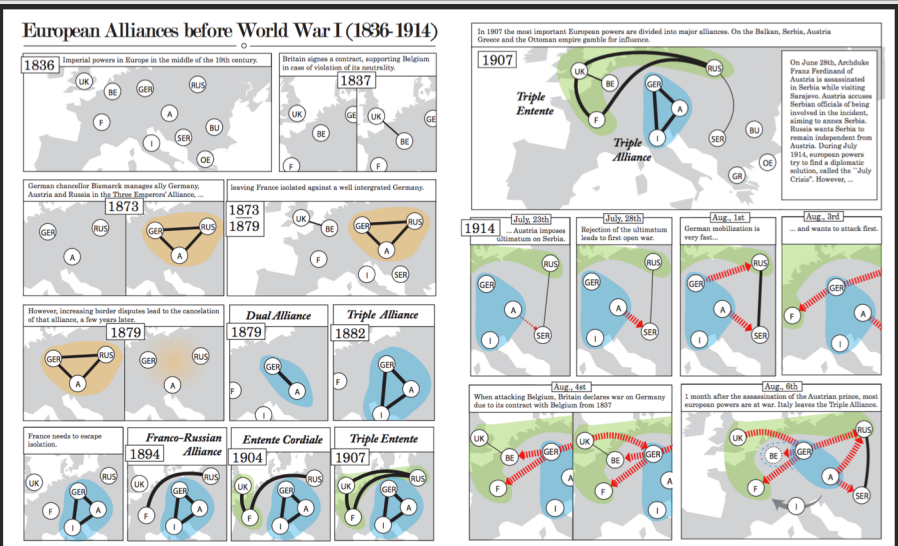
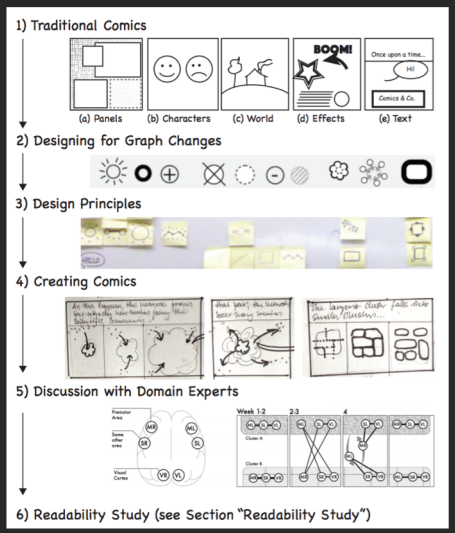


Figure 3. Graph comic example illustrating historical events preceeding WWI, targeted to a general audience.

Graph Comics [Bach et al. 2016]

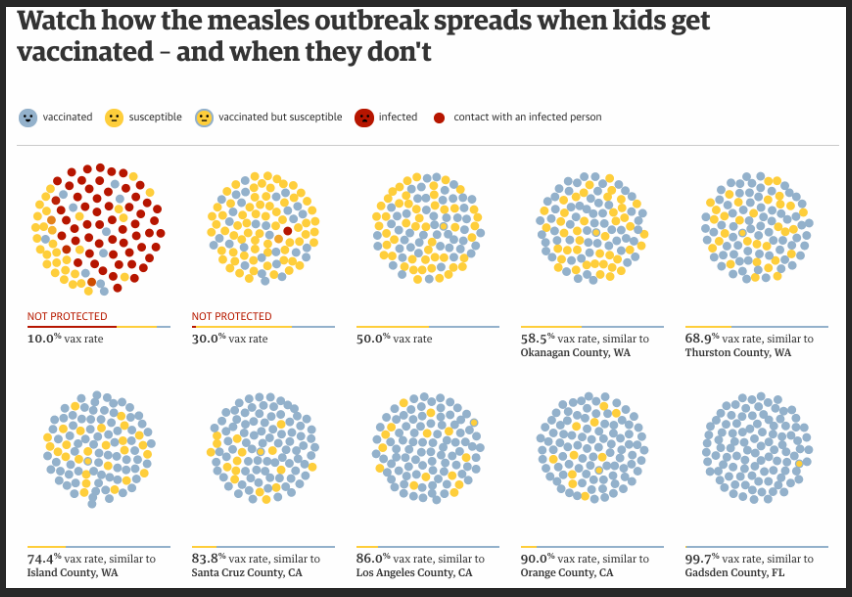
Narrative theory applied

C1. Element identity—Characters in traditional comics are recognizable via their distinct visual features. In graph visualization, nodes and edges are usually represented by circles, sometimes using labels for identifications. Variations in shape and color reflect attributes in the data.
C2. Depicting change—In comics, readers can infer changes even if not shown explicitly. For example, a baby being shown implies it has been born. In graphs, a (new) node being shown does not mean it was not there before.
C3. Order of events—Many changes exhibit a natural order (e.g. humans grow old, objects fall down, day turns into night). Changes in graphs do not have a natural order nor duration; a cluster can grow or shrink, divide or merge.
C4. Spatial context—In comics, the spatial context of a scene is usually indicated by the panel background: the same background means the same place and often the same scene. Switching spatial context from one cluster to another may not be recognized by a reader (both consists of nodes and links).
C5. Number of elements—Comics usually show a small set of characters in every panel. Changes in graphs, may involve many more elements than it is possible to show in a panel.

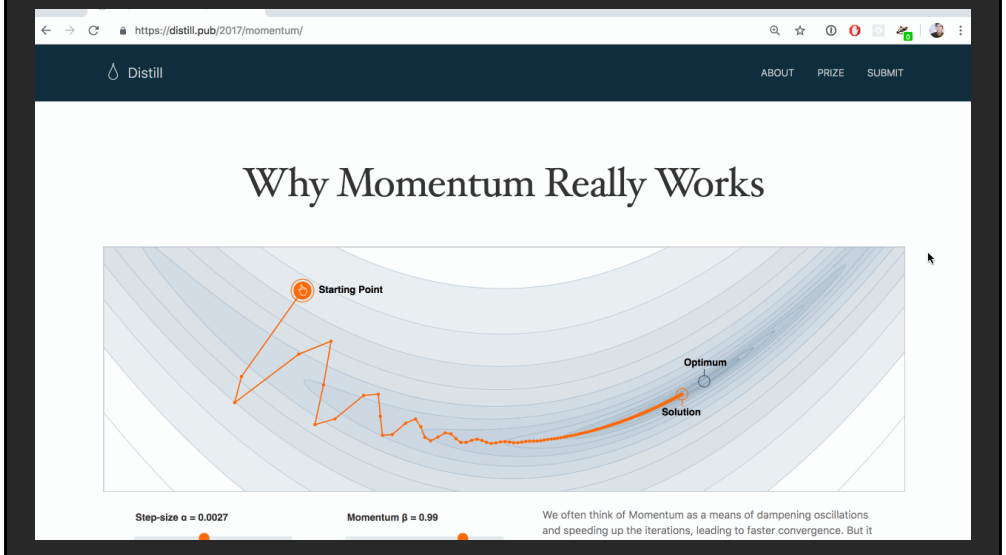


Graph Comics [Bach et al. 2016]

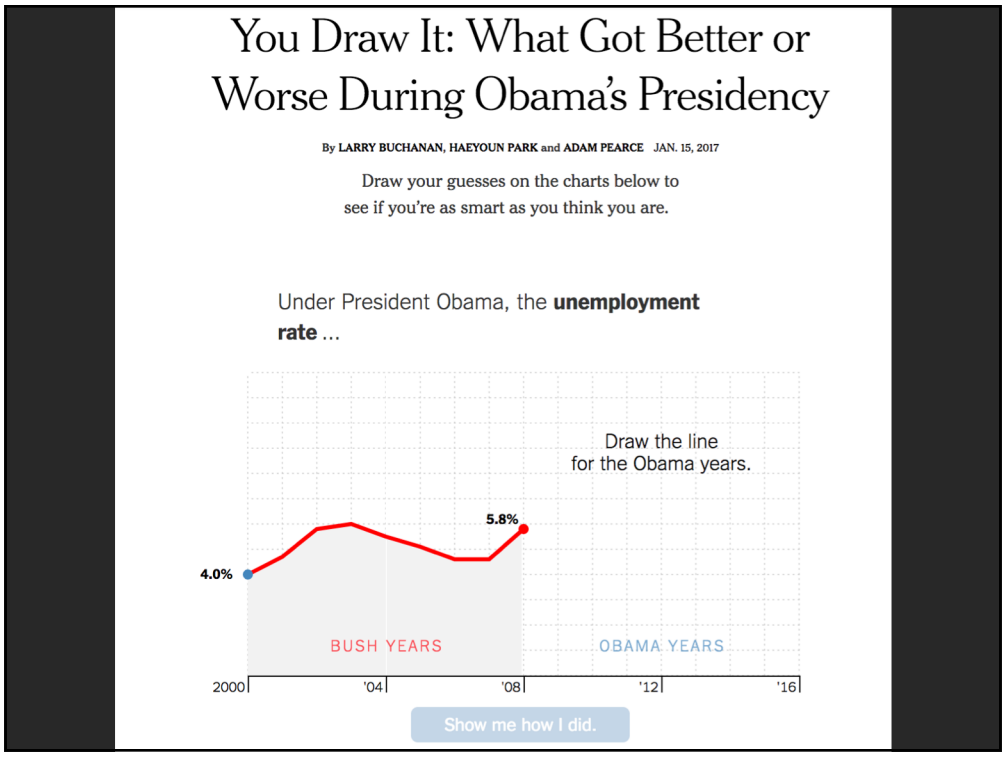
Interactive Documents

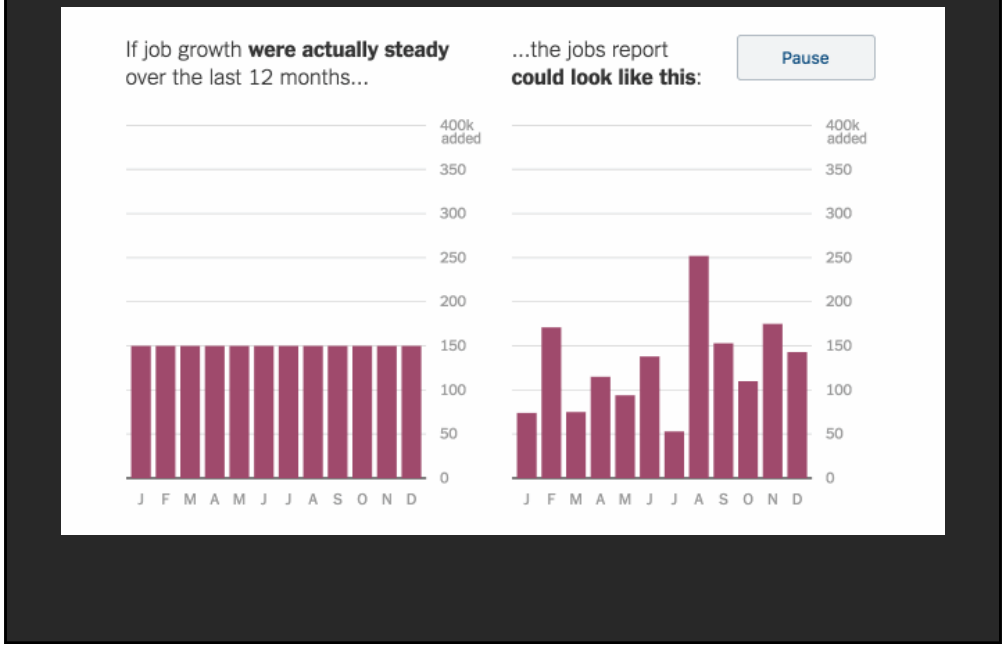


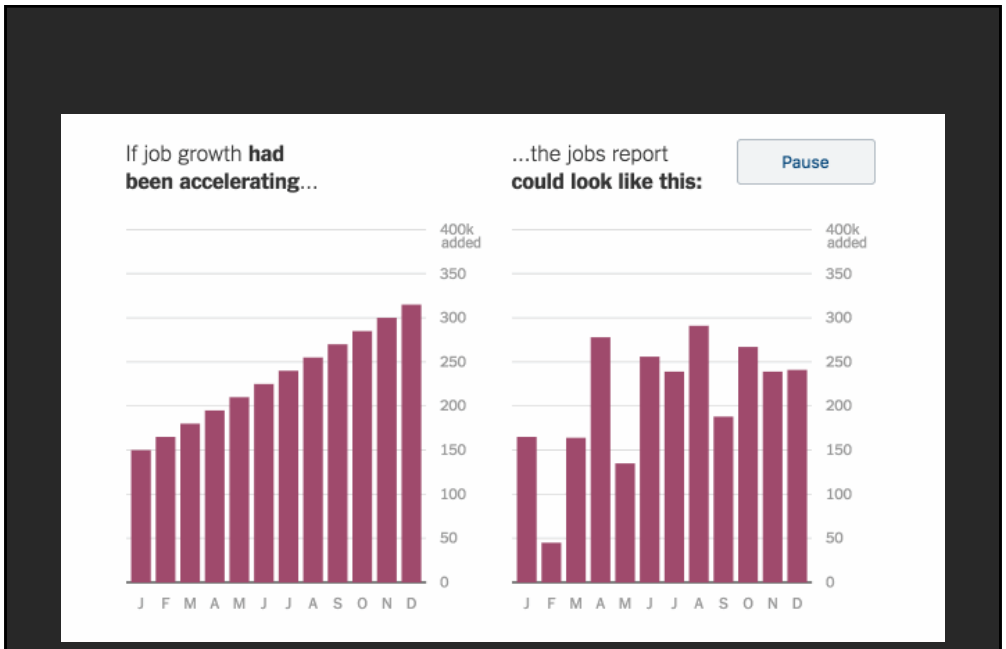
Who Should Get Parole?
Even the best risk assessments yield probabilities, not certainties. That means they label as "high risk" some people who won't commit another crime and label as "low risk" some people who will. This simulation lets you sort offenders into risk categories based on the results of an assessment. Think we should rarely lock up anyone who wouldn't reoffend? Set the "low risk" threshold high and the "high risk" threshold even higher. Have little tolerance for recidivism? Try the opposite. In the real world, policymakers have to strike a balance. Read more »
1
The prisoners in this simulation are up for parole. Some will reoffend if released and some won't. They each take an assessment, which estimates the chance they will reoffend.
2
Prisoners are placed in one of three categories based on these estimates. Move the slider to change the cutoffs for each category. "Low risk" prisoners will be awarded parole. "High risk" prisoners will be denied.
33
67%
3
Some people you let out reoffended. Some people you left in prison wouldn't have. Are you OK with the results?
Stop
PARO
LE-ELIGIBLE
PRISONERS
- Will reoffend
- Will not reoffend
LOW RISK
MEDIUM RISK
HIGH RISK
AWARDED PAROLE
18%
AWARDED PAROLE AND THEN REOFFENDED
DENIED PAROLE
14%
DENIED PAROLE BUT WOULDN'T HAVE REOFFENDED

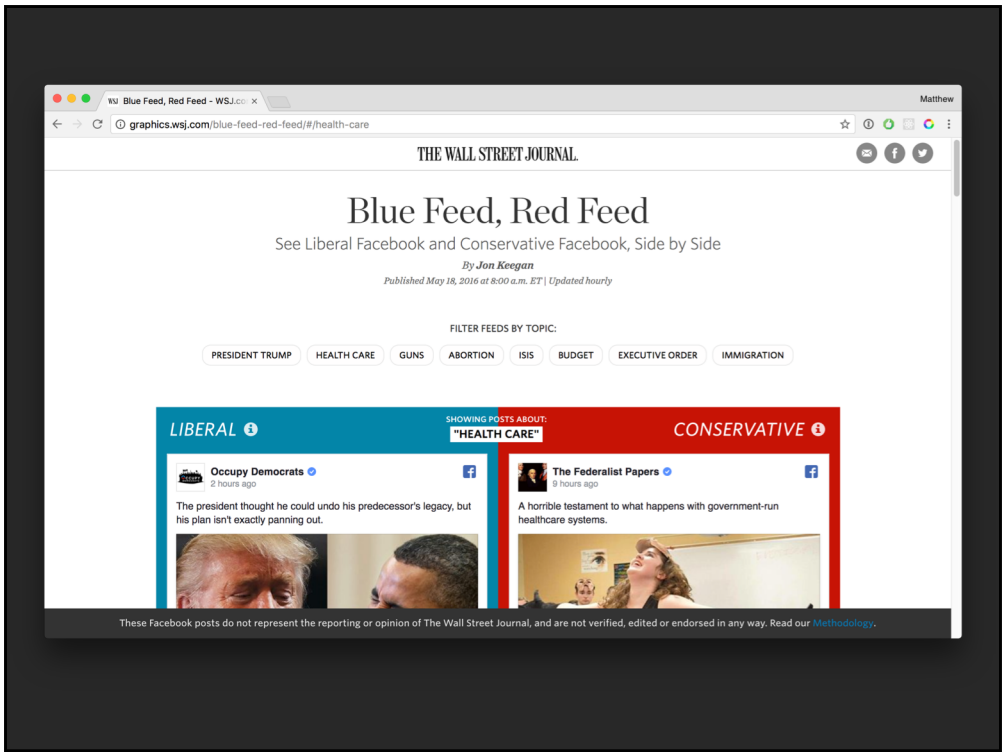

https://distill.pub/2017/momentum/
Distill
ABOUT
PRIZE
SUBMIT
Why Momentum Really Works
Starting Point
Optimum
Solution
Step-size α = 0.0027
Momentum β = 0.99
We often think of Momentum as a means of dampening oscillations and speeding up the iterations, leading to faster convergence. But it

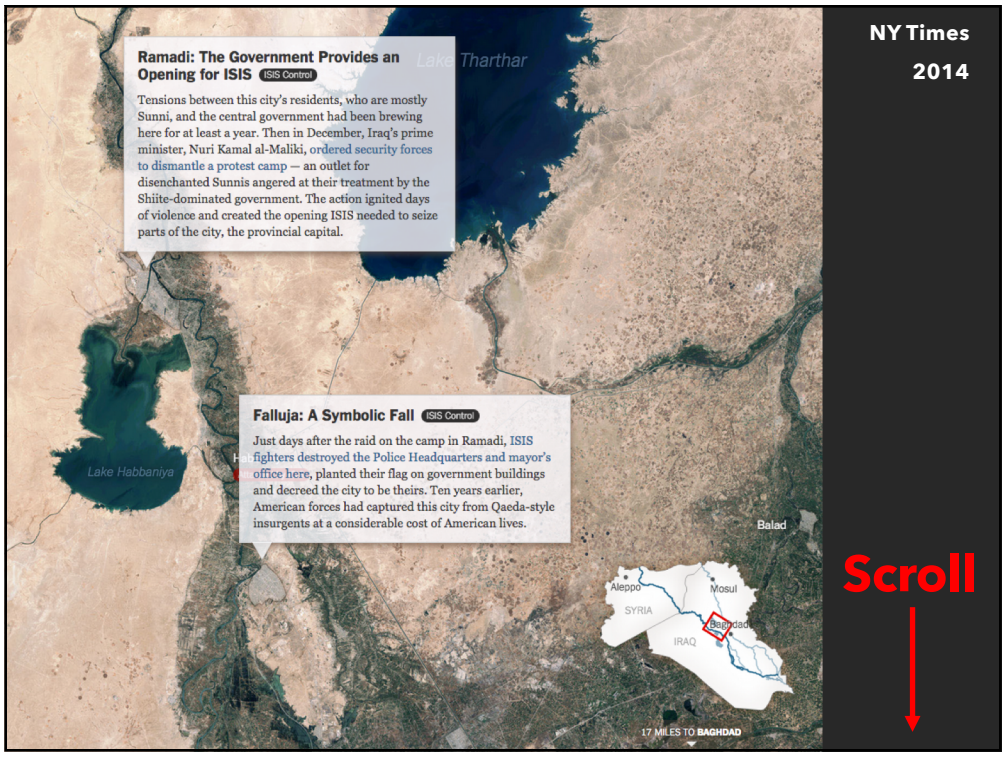
I am female White and currently 23 years old. LIVE
AGE OF DEATH
23 years
DIED SO FAR
1%
STILL ALIVE
99%
CAUSE OF DEATH SO Ffar
0% Infection
0% Cancer
0% Blood
0% Endocrine
0% Mental
0% Nervous
0% Circulatory
0% Respiratory
0% Digestive
0% Musculoskeletal
0% Genitourinary
0% Perinatal
0% Congenital
0% External Causes
0% Other


You Draw It: What Got Better or Worse During Obama's Presidency
By LARRY BUCHANAN, HAEYOUN PARK and ADAM PEARCE JAN. 15, 2017
Draw your guesses on the charts below to see if you're as smart as you think you are.
Under President Obama, the unemployment rate ...
Draw the line for the Obama years.
5.8%
4.0%
BUSH YEARS
OBAMA YEARS
2000
'04
'08
'12
'16
Show me how I did.


If job growth **were actually steady** over the last 12 months...
...the jobs report **could look like this**:
Pause
400k added
350
300
250
200
150
100
50
0
J F M A M J J A S O N D


If job growth **had been accelerating**...
...the jobs report **could look like this:**
Pause
400k added
350
300
250
200
150
100
50
0
J F M A M J J A S O N D


Blue Feed, Red Feed - WSJ.com
graphics.wsj.com/blue-feed-red-feed/#/health-care
Matthew
THE WALL STREET JOURNAL.
Blue Feed, Red Feed
See Liberal Facebook and Conservative Facebook, Side by Side
By Jon Keegan
Published May 18, 2016 at 8:00 a.m. ET | Updated hourly
FILTER FEEDS BY TOPIC:
PRESIDENT TRUMP
HEALTH CARE
GUNS
ABORTION
ISIS
BUDGET
EXECUTIVE ORDER
IMMIGRATION
LIBERAL
SHOWING POSTS ABOUT:
"HEALTH CARE"
CONSERVATIVE
Occupy Democrats
2 hours ago
The president thought he could undo his predecessor's legacy, but his plan isn't exactly panning out.
The Federalist Papers
9 hours ago
A horrible testament to what happens with government-run healthcare systems.
These Facebook posts do not represent the reporting or opinion of The Wall Street Journal, and are not verified, edited or endorsed in any way. Read our Methodology.


Ramadi: The Government Provides an Opening for ISIS
ISIS Control
Tensions between this city's residents, who are mostly Sunni, and the central government had been brewing here for at least a year. Then in December, Iraq's prime minister, Nuri Kamal al-Maliki, ordered security forces to dismantle a protest camp — an outlet for disenchanted Sunnis angered at their treatment by the Shiite-dominated government. The action ignited days of violence and created the opening ISIS needed to seize parts of the city, the provincial capital.
Lake Tharthar
Falluja: A Symbolic Fall
ISIS Control
Just days after the raid on the camp in Ramadi, ISIS fighters destroyed the Police Headquarters and mayor's office here, planted their flag on government buildings and decreed the city to be theirs. Ten years earlier, American forces had captured this city from Qaeda-style insurgents at a considerable cost of American lives.
Lake Habbaniya
Balad
Aleppo
Mosul
SYRIA
Baghdad
IRAQ
17 MILES TO BAGHDAD
NY Times
2014
Scroll

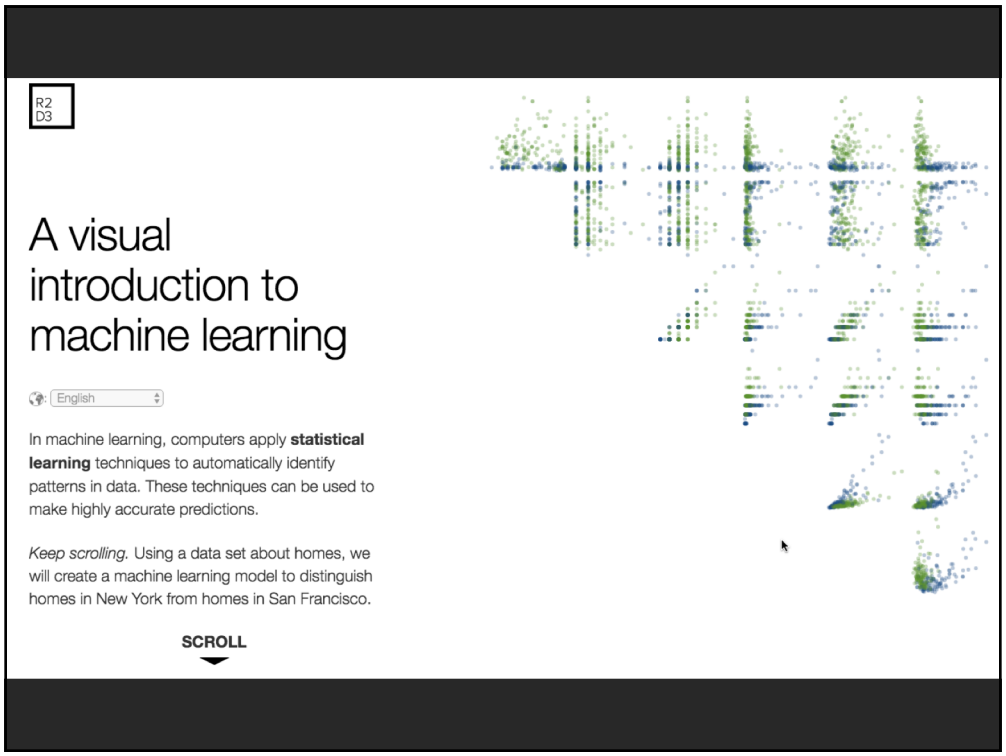
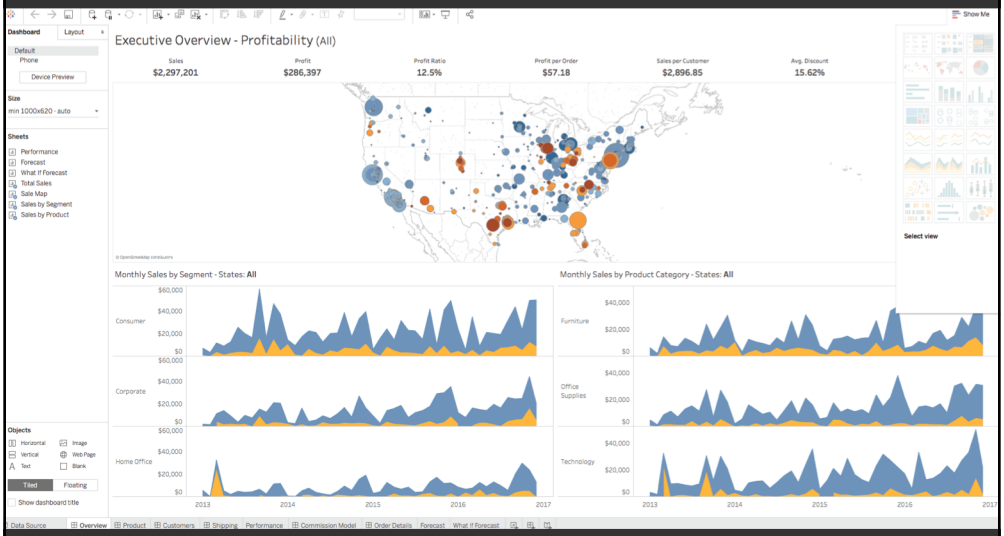


Chart Sequences

Multiple Charts in Data Analysis



Multiple Charts in Storytelling

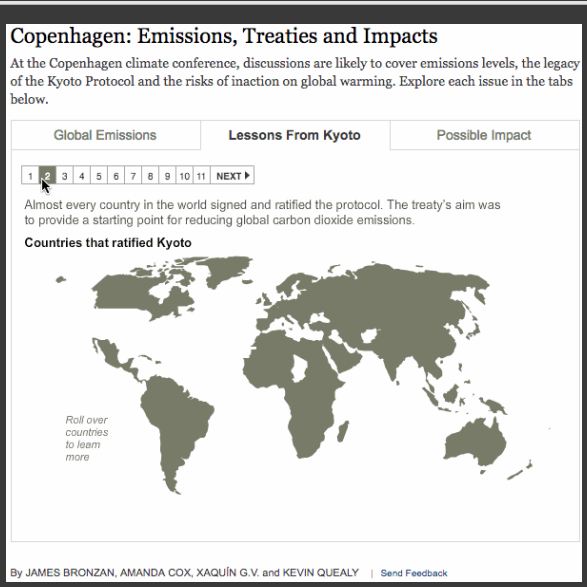
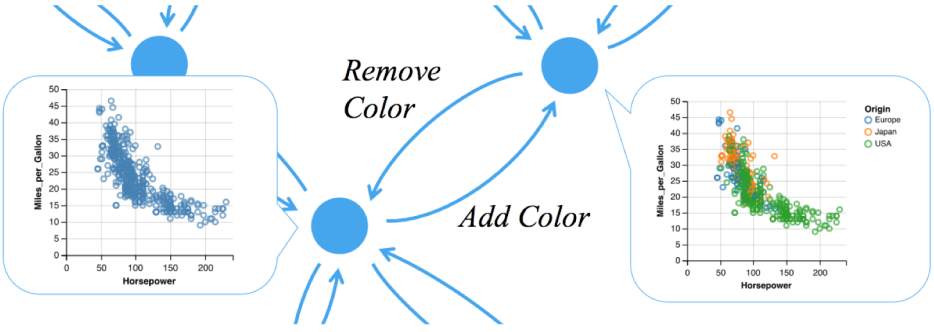


Chart Sequence Design [Hullman 2013]

Can we automatically identify sequences to recommend to a human designer?

GraphScape: A Directed Graph Model

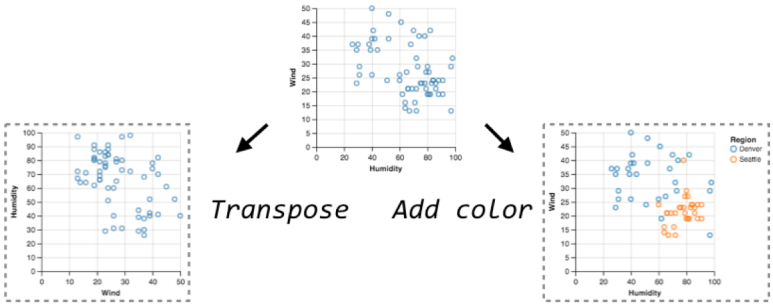


Nodes are **Vega-Lite specifications**. Edges represent **edit operations**, weighted by estimated **transition costs**.

[Kim, Wongsuphasawat, Hullman, Heer, 2017]

Constructing the Graph

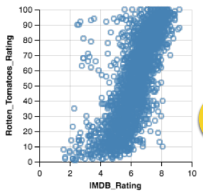
After reading this chart,



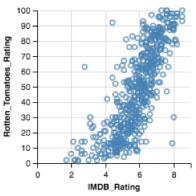
which chart is easier to follow?

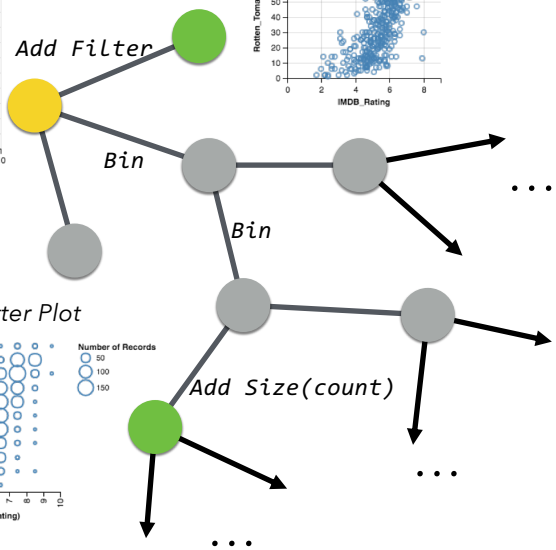
Design Alternatives

"Too many data points !"

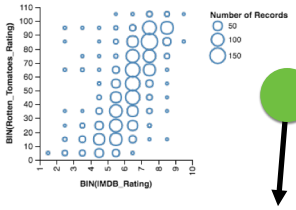


Random Sample

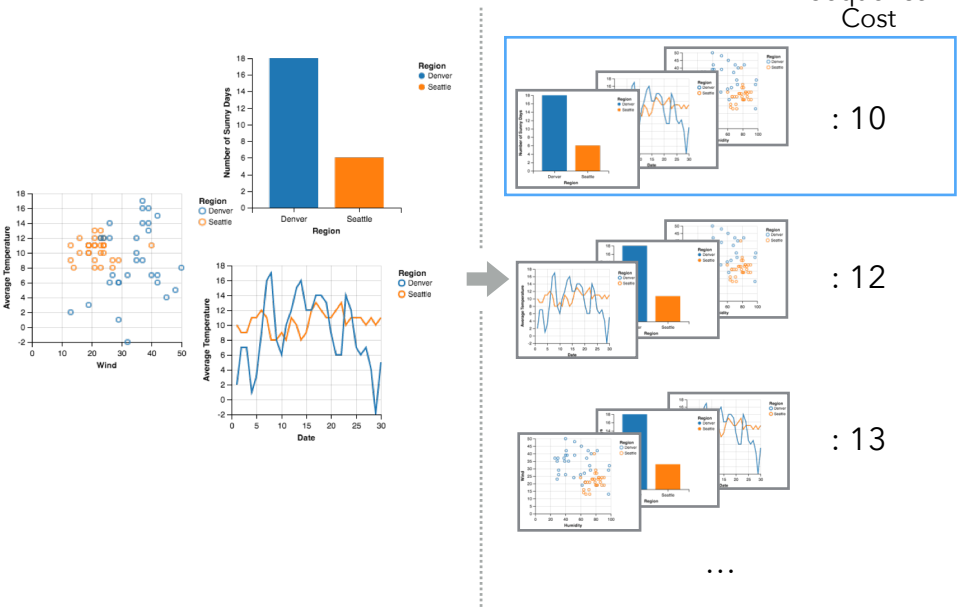




Binned Scatter Plot



Sequence Recommendation



GraphScape [Kim, Wongsuphasawat, Hullman, Heer 2017]

Previously we've discussed approaches for automatic design of a single visualization (e.g. Mackinlay's APT)

GraphScape supports automated design methods for collections of visualizations.

Plenty of future work to do here!

Summary

Narrative visualizations blend communication via imagery and text with interaction techniques

Specific strategies can be identified by studying what expert designers make

Automating construction of effective explainers is an active area of Visualization research