

# Visual Explainers

*Maneesh Agrawala*

**CS 448B: Visualization  
Winter 2020**

with material from Matthew Conlen and Jessica Hullman

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## Topics

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

2

# Storytelling

3

## As ancient as mankind

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4

# All media tell stories

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**PEOPLE** TELL STORIES

**WORDS** TELL STORIES

**IMAGES** TELL STORIES

**COMICS** TELL STORIES

**MOVIES** TELL STORIES

**VISUALIZATIONS** TELL STORIES

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# Narrative Storytelling

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**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

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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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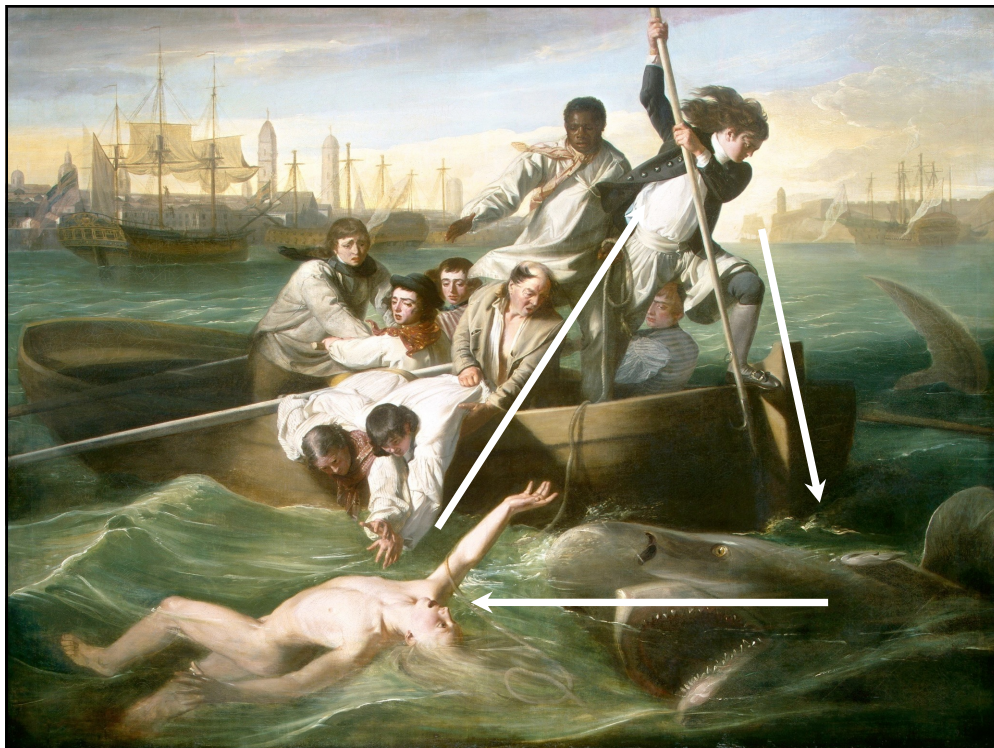
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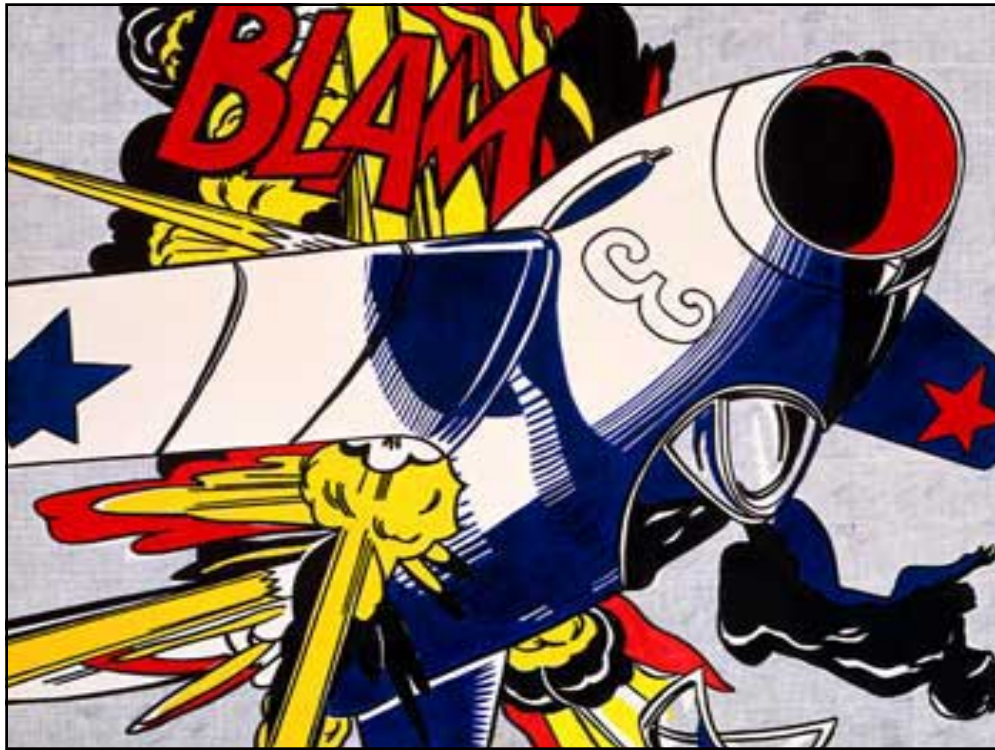
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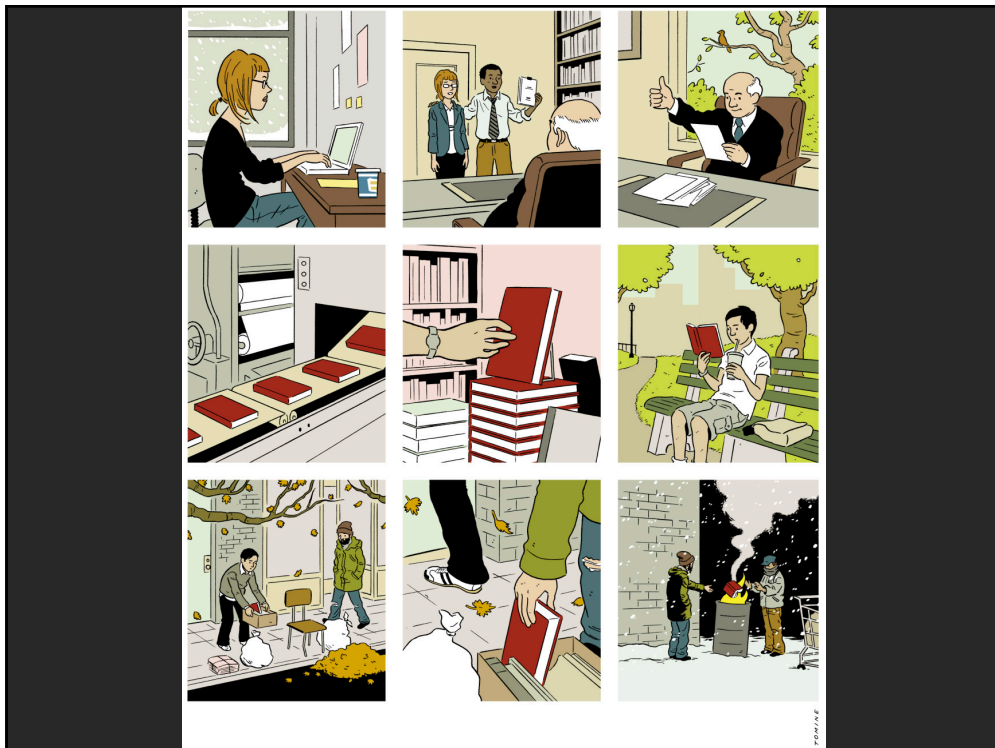
9



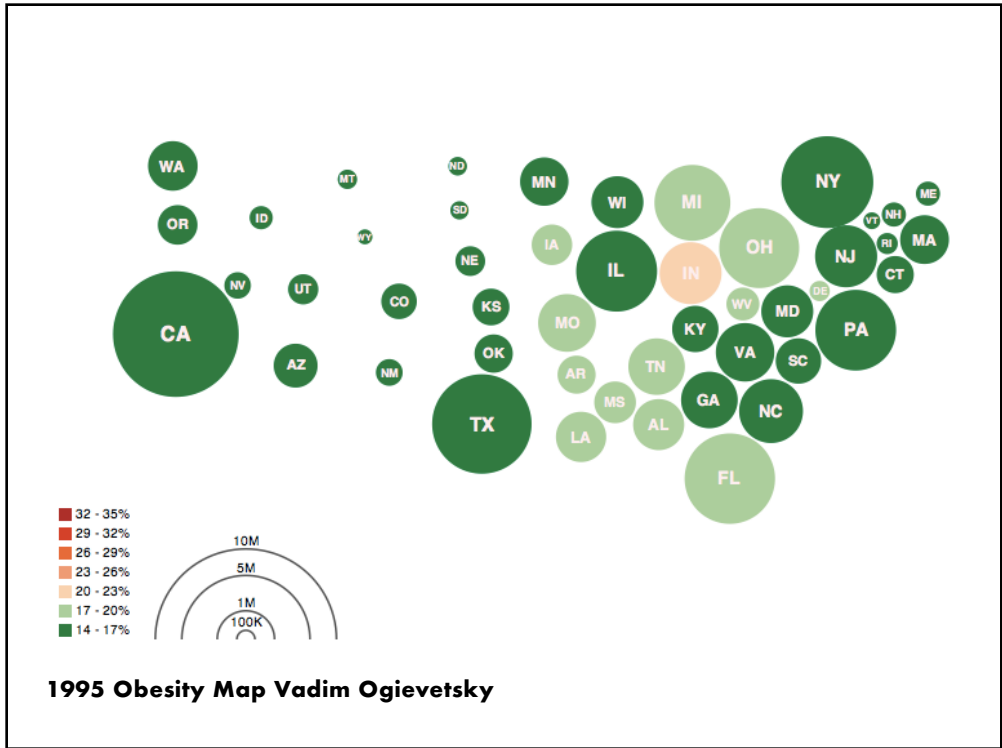
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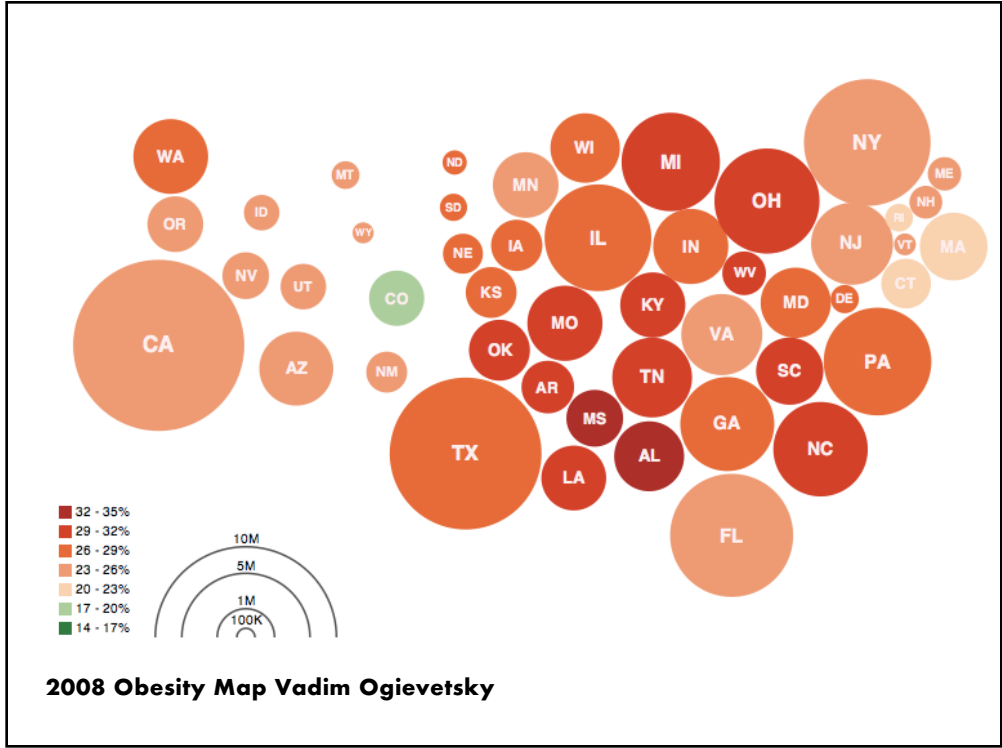
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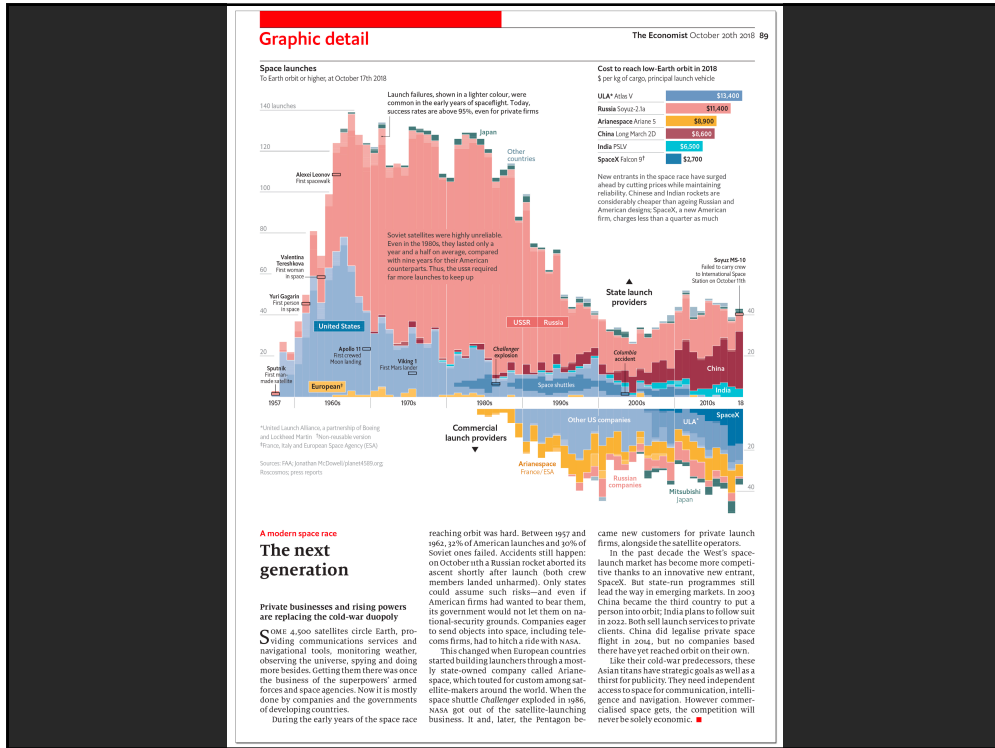
12



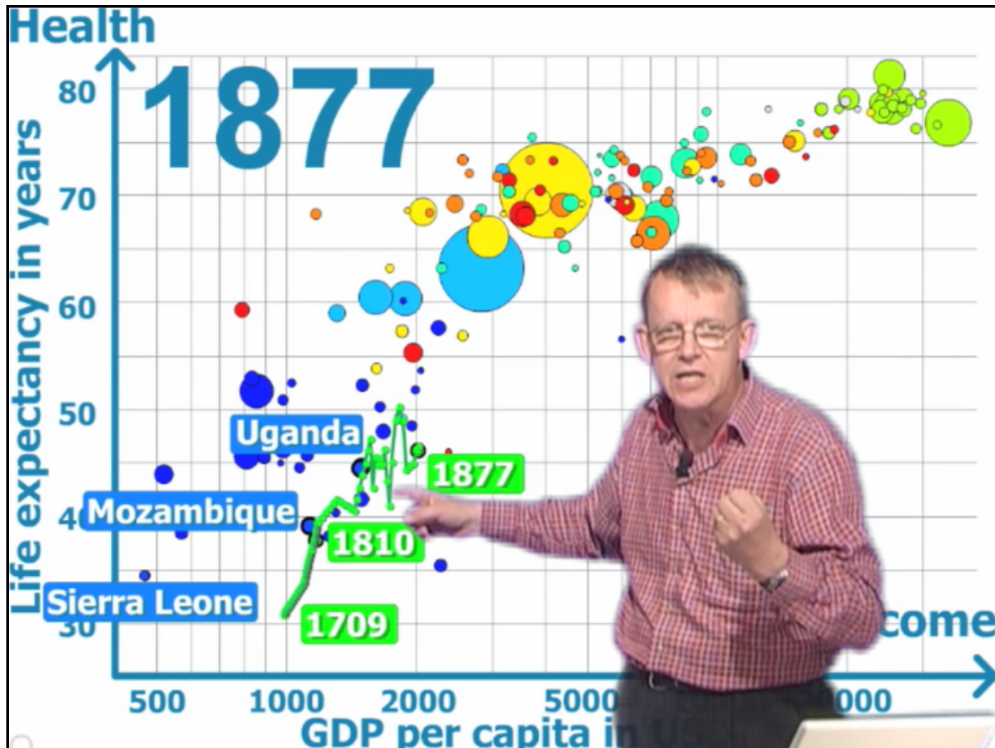
13



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15



18



# Design Space of Narrative Visualization

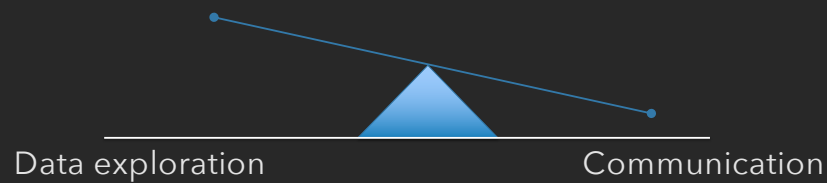
19

## Value of storytelling [Gershon and Page 2001]

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### A way of structuring information

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



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**58**  
**CASE STUDIES**

**70% Journalism**  
**20% Business**  
**10% Research**

[Segel & Heer 2010]

21

**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.

**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.

**Others Taking Aim**

**Albert Pujols**  
Averaging 40 homers a season, he has started stronger than the three leaders did.

**Ken Griffey Jr.**  
Many thought he would be the first to catch Ruth and Aaron until injuries limited his output.

**Alex Rodriguez**  
Youngest to reach 400 homers.

**Albert Pujols**  
Second most ever in first five seasons.

**Differing Paths to the Top of the List**

**Hank Aaron** 755  
15 times hit 30 or more (M.L. most)

**Babe Ruth** 714  
Hit only 20 over first five seasons.

**Barry Bonds** 738  
Averaged 52 from 2000 to 2004.

**Willie Mays** 660  
No one hit more from 1950-69.

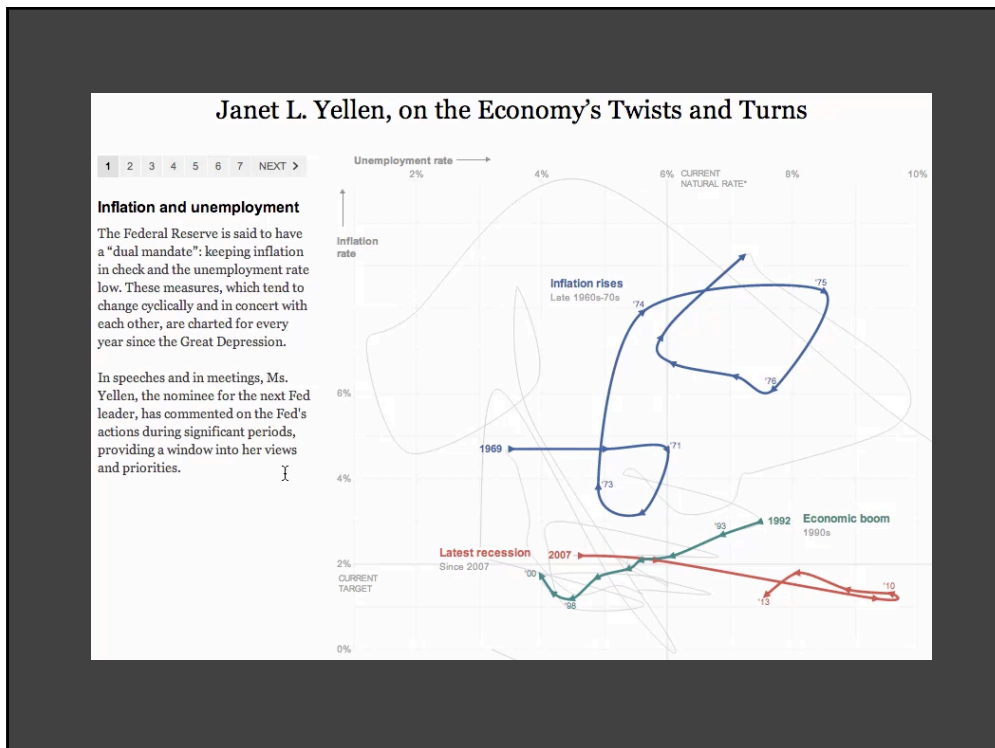
**Sam Rice** 588  
Three seasons record: (49, 122, 316) a season more in the 90's.

Note: Ages as of July 1 of each season.

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23



26

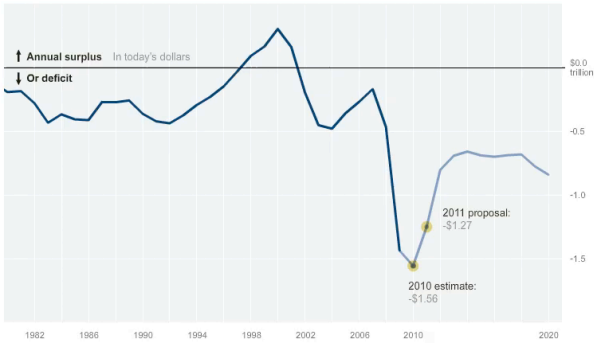
## Budget Forecasts, Compared With Reality

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.



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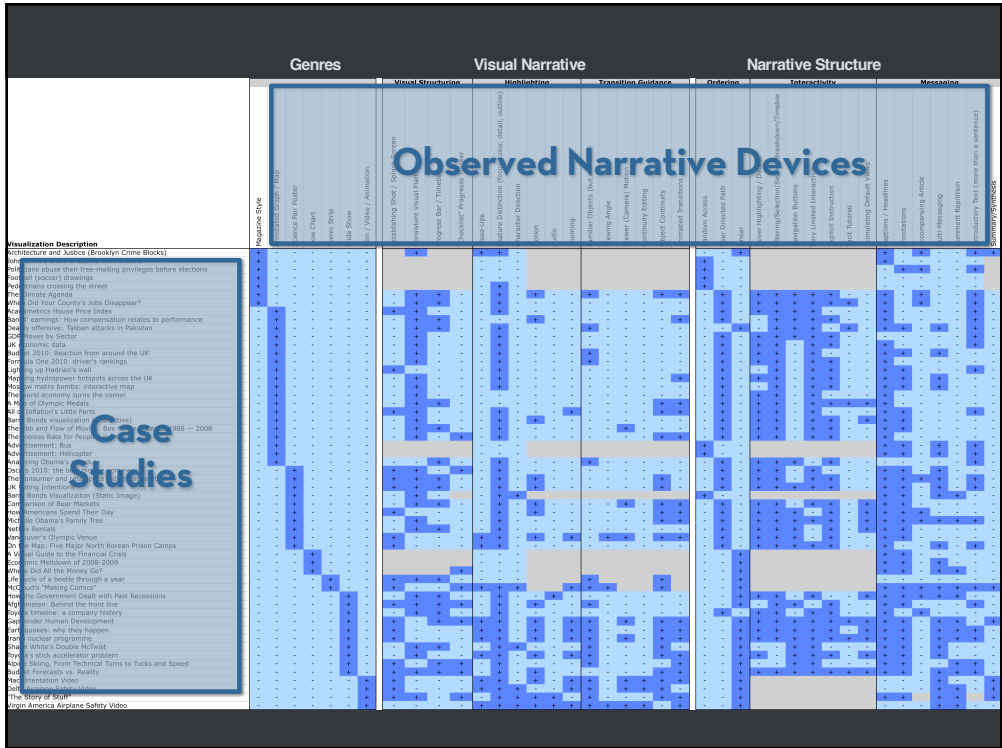
29

### Seven Genres

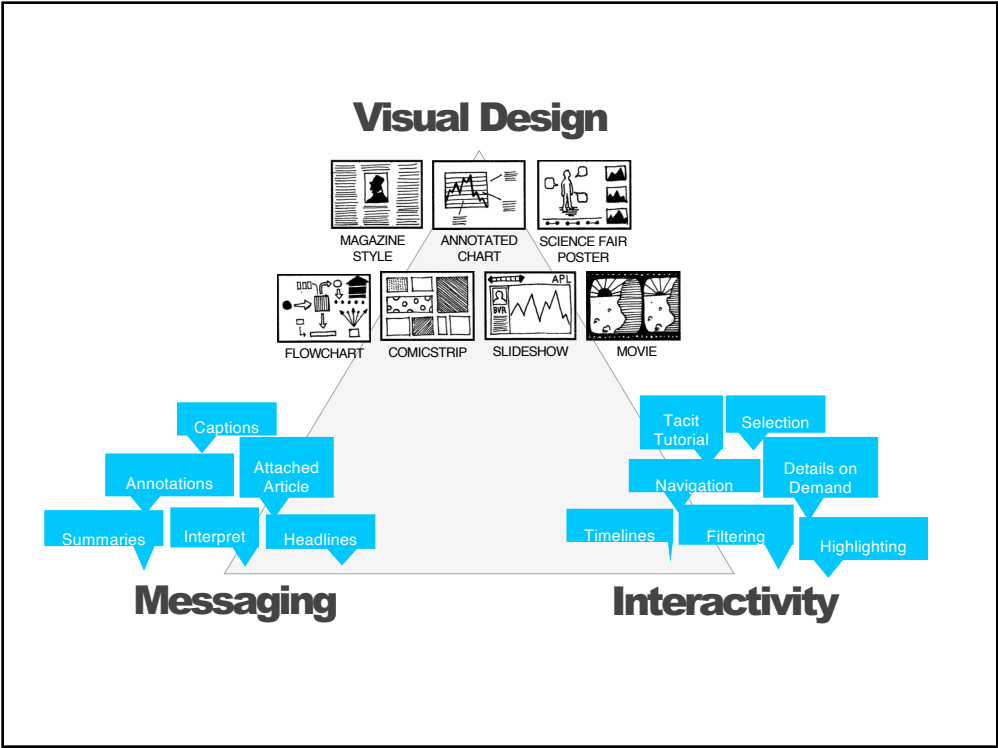
Magazine Style	Annotated Chart	Partitioned Poster
Flow Chart	Comic Strip	Slide Show
Film/Video/Animation		

**Genres for Narrative Visualization (Segel & Heer 2010)**

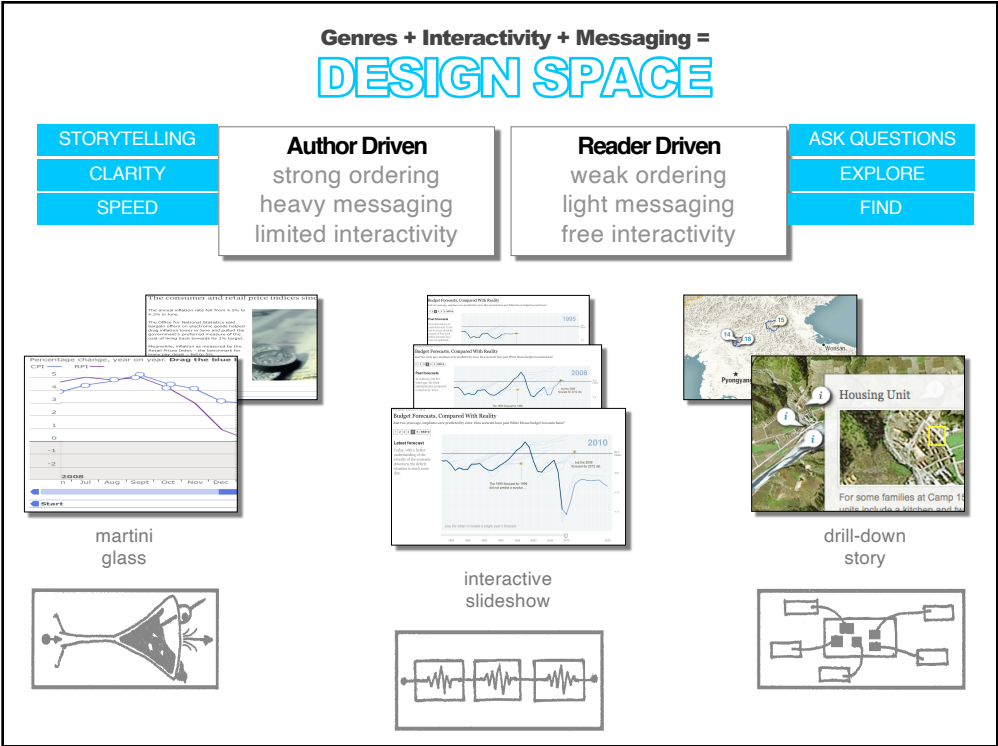
30



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32



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# 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\*

```

FABLE → STORY AND MORAL
STORY → SETTING AND EVENT STRUCTURE
SETTING → { STATE* (AND EVENT*) }
EVENT* → { STATE* (AND STATE*) }
STATE* → STATE ( (AND STATE)* )
EVENT* → EVENT ( ( { AND } { THEN } ) EVENT* ) ( (AND STATE)* )
          { CAUSE }
EVENT STRUCTURE → EPISODE ( (THEN EPISODE)* )
EPISODE → BEGINNING CAUSE DEVELOPMENT CAUSE ENDING
BEGINNING → { EVENT* }
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 }
EMPHASIS → STATE
    
```

Remembrance of Things Parsed [Mandler and Johnson 1977]

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# Narrative theory applied

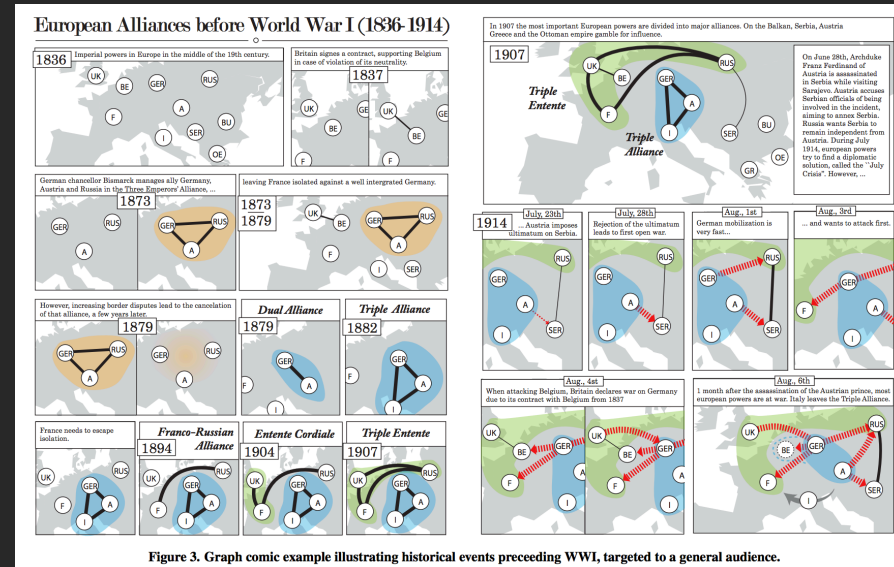


Figure 3. Graph comic example illustrating historical events preceding WWI, targeted to a general audience.

Graph Comics [Bach et al. 2016]

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# Narrative theory applied

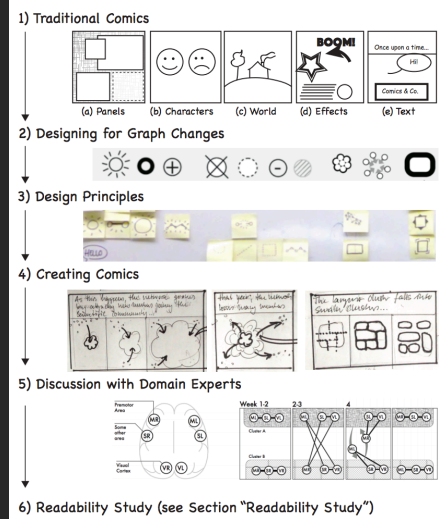
**C1. Element identity**—Characters in traditional comics are recognizable via their distinct visual features. In graph visualization, nodes and edges are usually represented by circles, sometimes using labels for identifications. Variations in shape and color reflect attributes in the data.

**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]

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# Announcements

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# Final project

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## New visualization research or data analysis project

- **Research:** Pose problem, Implement creative solution
- **Data analysis:** Analyze dataset in depth & make a visual explainer

## Deliverables

- **Research:** Implementation of solution
- **Data analysis/explainer:** Article with multiple interactive visualizations
- 6-8 page paper

## Schedule

- Project proposal: **Wed 2/19**
- Design review and feedback: **3/9 and 3/11**
- Final poster presentation: **3/16 (7-9pm) Location: TBD**
- Final code and writeup: **3/18 11:59pm**

## Grading

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

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# Interactive Documents

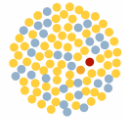
40

## Watch how the measles outbreak spreads when kids get vaccinated - and when they don't

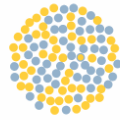
● vaccinated 
 ● susceptible 
 ● vaccinated but susceptible 
 ● infected 
 ● contact with an infected person



NOT PROTECTED  
10.0% vax rate



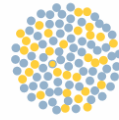
NOT PROTECTED  
30.0% vax rate



50.0% vax rate



58.5% vax rate, similar to Okanagan County, WA



68.9% vax rate, similar to Thurston County, WA



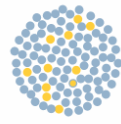
74.4% vax rate, similar to Island County, WA



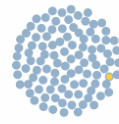
83.8% vax rate, similar to Santa Cruz County, CA



86.0% vax rate, similar to Los Angeles County, CA



90.0% vax rate, similar to Orange County, CA



99.7% vax rate, similar to Gadsden County, FL

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## 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

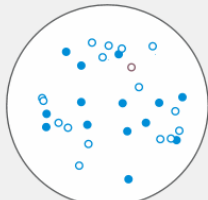
Prisoners are placed in one of three categories based on these estimates. **Move the slider** to change the cutoffs for each category. "Low risk" prisoners will be awarded parole. "High risk" prisoners will be denied.

3

Some people you let out reoffended. Some people you left in prison wouldn't have. **Are you OK with the results?**

Stop

PAROLE-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

42

← → ↻ https://distill.pub/2017/momentum/ 🔍 ☆ ⓘ 🔌 🌐 🌱 🌿 🌾 🌻 🌼 🌽 🌾 🌿 🌱

Distill ABOUT PRIZE SUBMIT

## Why Momentum Really Works

Starting Point Optimum Solution

Step-size  $\alpha = 0.0027$  Momentum  $\beta = 0.99$

We often think of Momentum as a means of dampening oscillations and speeding up the iterations, leading to faster convergence. But it

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I am female White and currently 23 years old.

AGE OF DEATH	DIED SO FAR	STILL ALIVE
23 years	1%	99%

CAUSE OF DEATH SO FAR

- 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

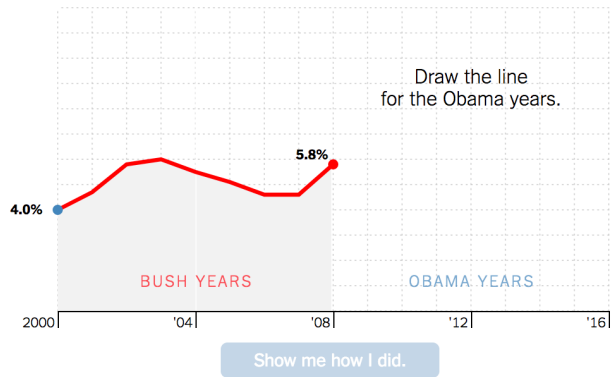
44

# You Draw It: What Got Better or Worse During Obama's Presidency

By LARRY BUCHANAN, HAEYOUN PARK and ADAM PEARCE JAN. 15, 2017

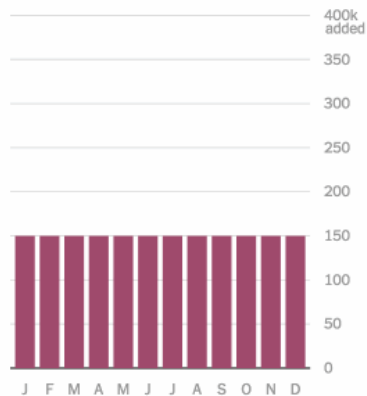
Draw your guesses on the charts below to see if you're as smart as you think you are.

Under President Obama, the **unemployment rate** ...



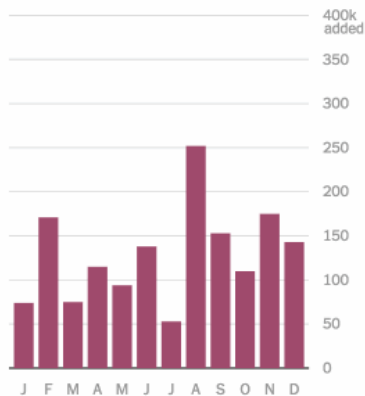
45

If job growth **were actually steady** over the last 12 months...

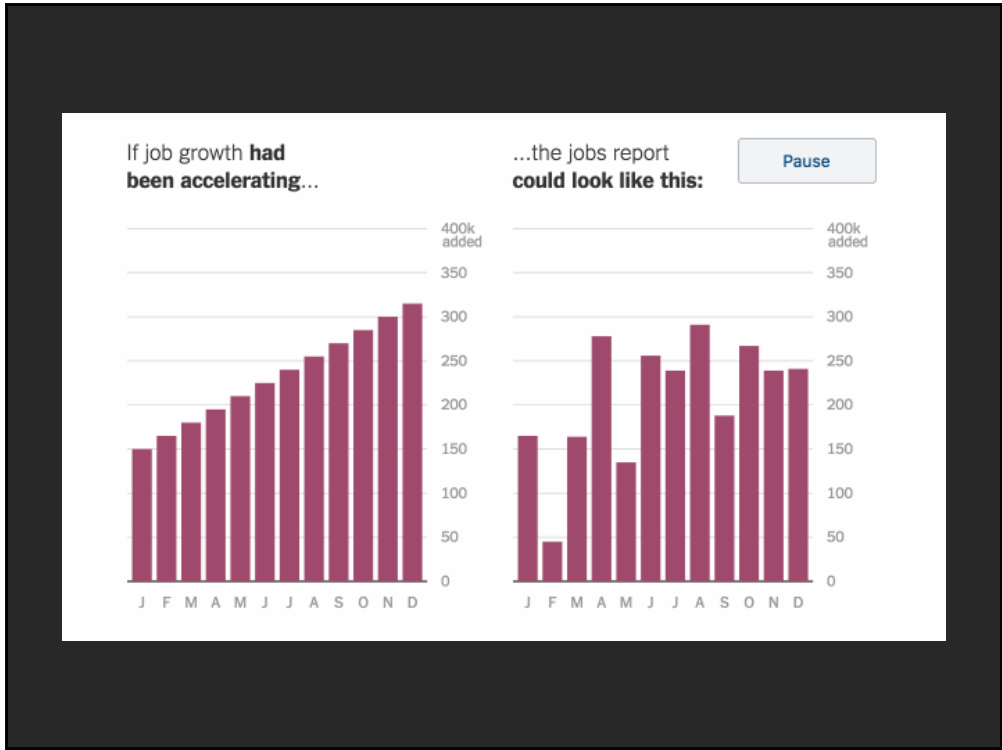


...the jobs report **could look like this:**

Pause



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**THE WALL STREET JOURNAL**

# Blue Feed, Red Feed

See Liberal Facebook and Conservative Facebook, Side by Side

By Jan 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**

**Occuply Democrats**  
2 hours ago

The president thought he could undo his predecessor's legacy, but his plan isn't exactly panning out.

**CONSERVATIVE**

**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](#).

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**NY Times**  
**2014**

**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 disenfranchised 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.

**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.

Aleppo  
SYRIA  
Mosul  
Baghdad  
IRAQ  
Balad  
17 MILES TO BAGHDAD

**Scroll**

50

R2  
D3

## A visual introduction to machine learning

English

In machine learning, computers apply **statistical learning** techniques to automatically identify patterns in data. These techniques can be used to make highly accurate predictions.

*Keep scrolling.* Using a data set about homes, we will create a machine learning model to distinguish homes in New York from homes in San Francisco.

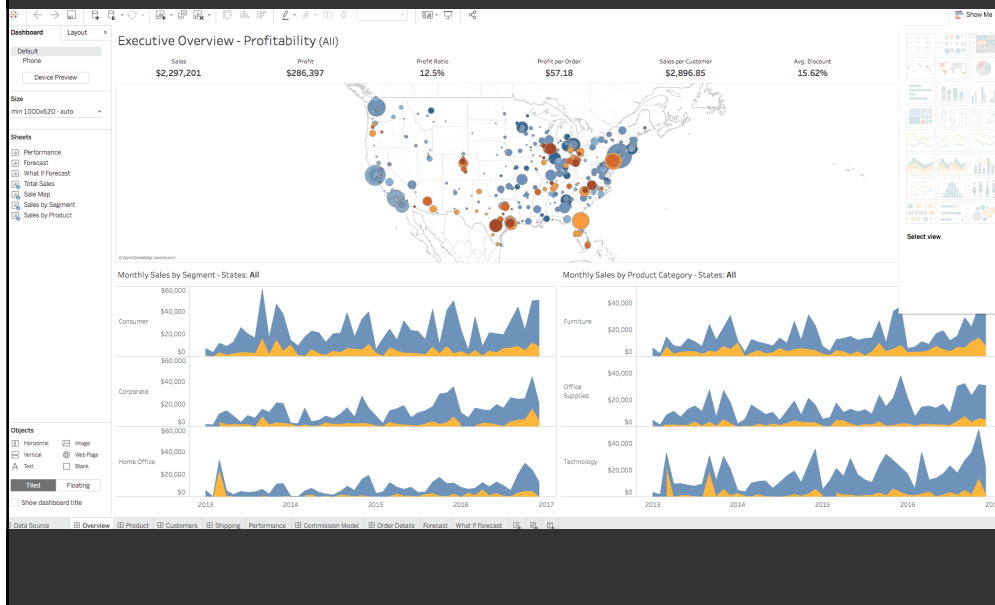
**SCROLL**

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# Chart Sequences

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# Multiple Charts in Data Analysis



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# Multiple Charts in Storytelling

## Copenhagen: Emissions, Treaties and Impacts

At the Copenhagen climate conference, discussions are likely to cover emissions levels, the legacy of the Kyoto Protocol and the risks of inaction on global warming. Explore each issue in the tabs below.

Global Emissions    **Lessons From Kyoto**    Possible Impact

1 2 3 4 5 6 7 8 9 10 11 NEXT ▶

Almost every country in the world signed and ratified the protocol. The treaty's aim was to provide a starting point for reducing global carbon dioxide emissions.

**Countries that ratified Kyoto**



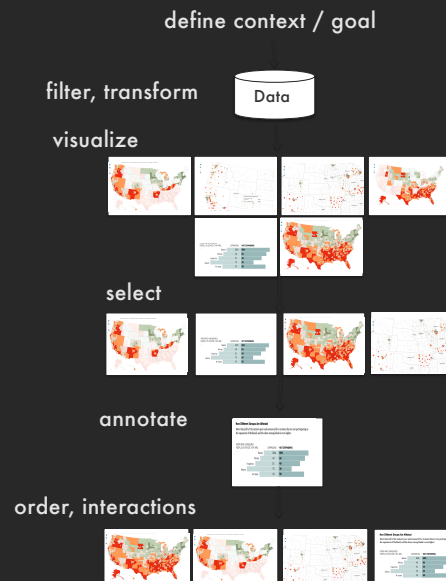
Roll over countries to learn more

By JAMES BRONZAN, AMANDA COX, XAQUÍN G.V. and KEVIN QUEALY | [Send Feedback](#)

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# Chart Sequence Design [Hullman 2013]

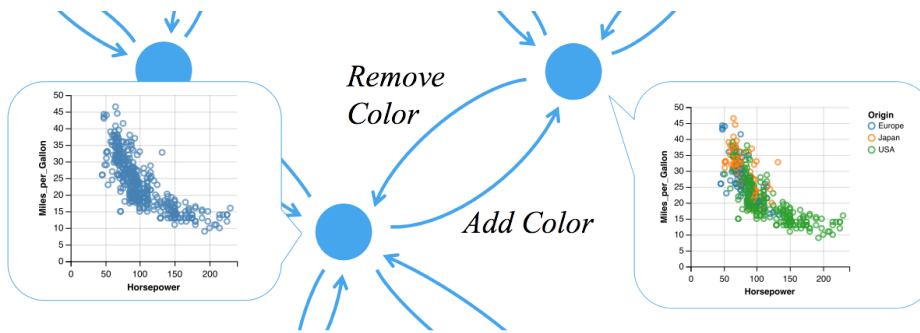
Can we automatically identify sequences to recommend to a human designer?



55



## GraphScope: A Directed Graph Model



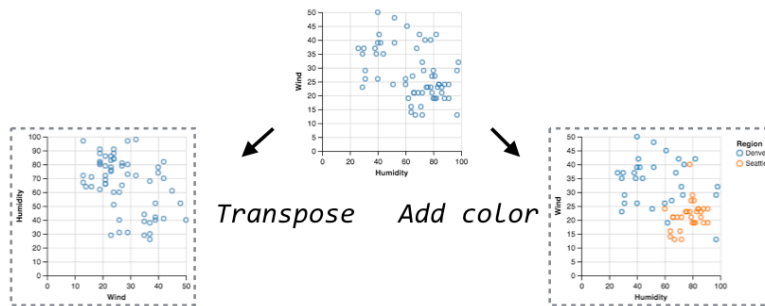
Nodes are Vega-Lite specifications. Edges represent edit operations, weighted by estimated transition costs.

[Kim, Wongsuphasawat, Hullman, Heer, 2017]

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## Constructing the Graph

After reading this chart,

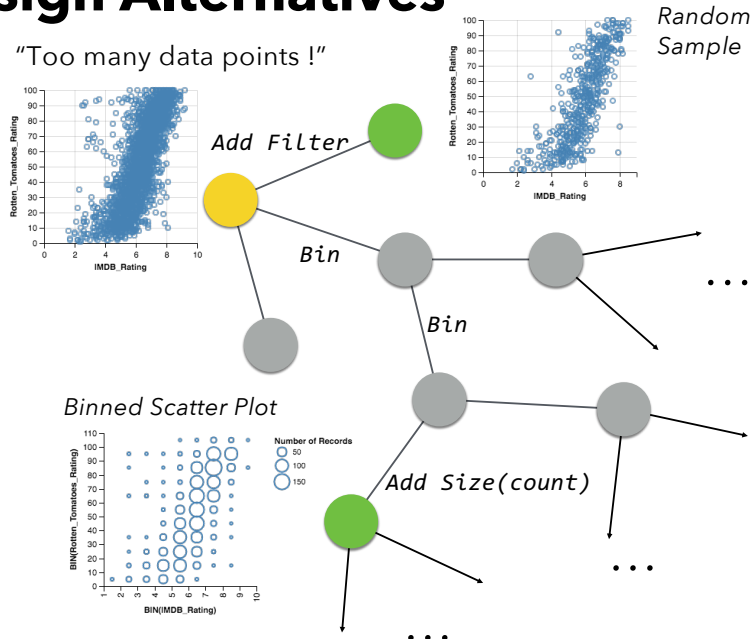


which chart is easier to follow?

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# Design Alternatives

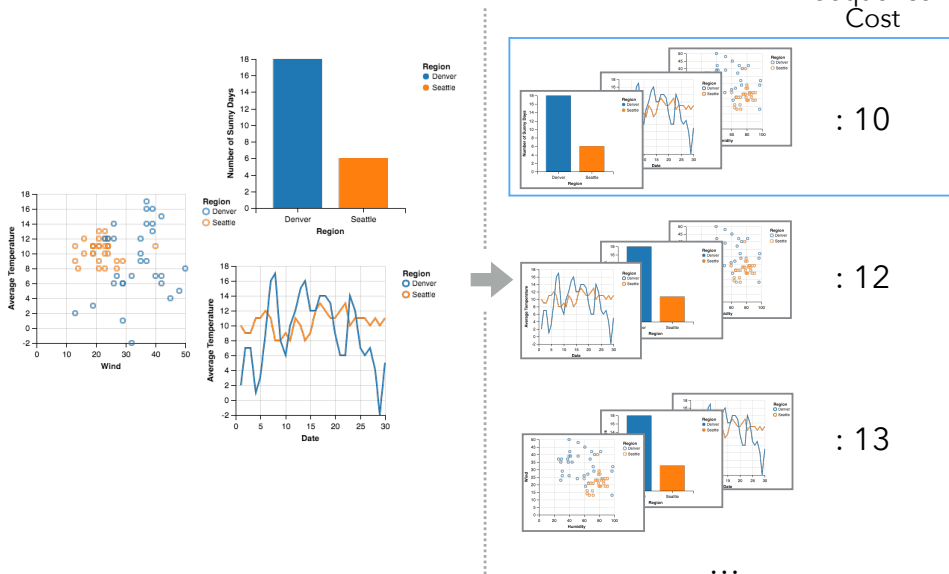
"Too many data points !"



58

# Sequence Recommendation

Sequence Cost



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# 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!

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# 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

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